DEPARTMENT OF PREVENTIVE MEDICINE

NORTHWESTERN UNIVERSITY FEINBERG SCHOOL OF MEDICINE

50 Years of Impact on Public Health, Prevention, and Training 1972-2022

DEPARTMENT OF PREVENTIVE MEDICINE

NORTHWESTERN UNIVERSITY FEINBERG SCHOOL OF MEDICINE 1972 - 2022

"You know if you're really interested [in epidemiology and prevention] there are 4 stages. The first stage is to do some work on the mortality data. The second stage is find yourself a population or two and collect a cross-section of data in the population and then find yourself at the same time, or close thereto... populations you can do prospectively. And the third and fourth stages—get involved in intervention studies."

JEREMIAH STAMLER, MD FOUNDING CHAIR, 1972-1986

Phase 1

Defining Risk Factors for Cardiovascular Disease and Mortality in Midlife

Phase 2

Expanding Epidemiology–Early Adult and Midlife Determinants of Chronic Diseases

Phase 3

Expanding the Toolbox for Epidemiology, Analytics of Human Health, and Prevention of Disease

Phase 4

Addressing the Life Course of Chronic Diseases and Healthy Aging

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"We are always seeking that next great collaboration that can move the needle on disease prevention and health promotion."

DONALD LLOYD-JONES, MD, SCM CHAIR, DEPARTMENT OF PREVENTIVE MEDICINE



Donald Lloyd-Jones, Chair; Mercedes Carnethon, Vice Chair, Department of Preventive Medicine

T ITS DECENNIAL DEPARTMENTAL REVIEW by Northwestern University in 2016, the Department of Preventive Medicine was heralded as "a national treasure" by the external reviewers, who included leading experts in the fields of epidemiology, public health, prevention, and biostatistics. This monograph reviews the founding, early work, and evolution of the department, and places in context its extraordinary impact on human health.

The book takes a historical perspective, dividing the life course of the department into four phases that describe areas of scientific work and expertise as the department drove the scientific agenda around health promotion and disease prevention. In turn, advances in scientific methods, research tools, analytical approaches, and prevention strategies evolved and shaped the growth and focus of the department's work as well. As the department celebrates the 50th anniversary of its founding in 2022, it is fitting that we recall the key research projects, the educational programs, and, especially, the remarkable people who have made this department a national treasure.



Phase 1

Defining Risk Factors for Cardiovascular Disease and Mortality in Midlife





A young Jeremiah Stamler at work

Top: Stamler, with two members of his department office staff, in his book-lined office on the ninth floor

N THE SUMMER OF 1972, JEREMIAH STAMLER BECAME THE FOUNDING CHAIR OF THE NEWLY CREATED DEPARTMENT OF COMMUNITY HEALTH AND PREVENTIVE MEDICINE.

Stamler was already world-renowned for his work in elucidating links between cholesterol and atherosclerosis and coronary disease, and in investigating dietary origins of risk factors, such as hypertension and hypercholesterolemia, in humans. As a member of the Chicago Board of Health and a faculty member of Northwestern's medical school from the late 1950s on, he had started seminal research programs examining lifestyle and physiologic factors, and had created public health screening and prevention programs focused on problems like rheumatic heart disease. Eager to learn more about the origins of human heart diseases, he brought his towering intellect, superior scientific skills, public health background, and innate curiosity to the founding of an academic department that could start to address these chronic problems that were at epidemic proportions and by far the leading causes of death in the U.S. From the department's inception, Stamler drove a research agenda that would address many of the largest public health issues of the 20th century, and he attracted faculty, trainees, and professional staff to help him conduct the research needed to advance that agenda.



Early Epidemiologic Studies in Cardiovascular Disease (CVD) and Their Continuing Legacies

From its founding to the present day, department faculty have been involved in research on the epidemiology, etiology, natural history, prognosis, and prevention of CVD, including coronary heart disease (CHD), stroke, and hypertension. This research has involved long-term, prospective, population-based epidemiological studies; cross-sectional and prospective studies of dietary, behavioral, and environmental factors related to optimal blood pressure and hypertension; and intervention trials on the prevention and control of high blood pressure and CHD by nutritional/ lifestyle means or by drugs.

Among the earliest long-term prospective epidemiological studies in which department faculty were involved were:

the Chicago People's Gas Company (PG) study, begun in 1958-59 in two cohorts of men, one numbering 1,594 male employees ages 40-59 in 1958 and the second numbering 1,609 male employees ages 25-39 in 1959;

the Chicago Western Electric Company study (WE), a long-term investigation of 2,100 male employees of the Hawthorne Works of the Western Electric Company in Chicago, ages 40-55 in 1957; and

the Chicago Heart Association Detection Project in Industry (CHA), a study of 39,573 Black or white men and women, primarily ages 18-64, screened from 1967 to 1973.

Data from these three studies formed the foundation of early department activity and led to comprehensive analyses on the roles of high blood pressure, hypercholesterolemia, cigarette smoking, overweight, alcohol intake, glycemia, diabetes, uricemia, education level, rapid heart rate, coffee intake, electrocardiographic abnormalities, and dietary cholesterol and beta-carotene as risk factors for deaths from all causes, CHD, stroke, other major CVDs, and cancers.

Jeremiah Stamler consults with a colleague in his office



Jeremiah Stamler sorting through slides

The strong associations with chronic disease outcomes observed in these analyses played a key role in the founding of the field of cardiovascular epidemiology and in identifying the major risk factors for CVD and mortality. In concert with similar findings from studies like the Framingham Heart Study, the discovery and confirmation of these chronic disease risk factors resulted in the establishment of public policies and clinical strategies to control them, and ultimately in the field of preventive cardiology.

Over decades (to the present day), participants in each of these studies were followed to determine vital status and cause of death to help answer questions on the epidemiology and etiology of adult CVD not fully elucidated by earlier prospective studies. This work involved early faculty, including Jeremiah Stamler, Rose Stamler, Alan Dyer, Kiang Liu, Linda Van Horn, and David Berkson.

Subsequent generations of faculty, including Martha Daviglus, Philip Greenland, and Norrina Allen, among others, perpetuated the funding and follow-up of the CHA cohort, which continues to provide insights into long-term cardiovascular, cancer, and mortality risks to the present. Linkage to Medicare data, available from the 1980s on, has extended the insights of the CHA cohort to allow for analyses of non-fatal events and healthcare utilization in the aging cohort over time. Such analyses have also included novel methods for assessing health care charges pioneered by Kiang Liu and Norrina Allen, and overall morbidity and compression of morbidity analyses led by Allen.

In 2009-2011, Daviglus led a follow-up study of the original CHA cohort, entitled the Chicago Healthy Aging Study (CHAS). CHAS participants were sampled for examination from the original CHA cohort based on the presence or absence of a low-risk state (with all optimal levels of traditional risk factors) in younger adulthood. Over 1,100 participants were examined in person approximately 40 years after their baseline examination in CHA, and measurements included anthropometric and health behavior data, physical functioning, blood measures, 12-lead electrocardiograms, carotid ultrasound, and carotid and coronary magnetic resonance angiography (in a subset of 440 participants). CHAS further cemented understanding of the long-term effects of low risk factor levels in younger adulthood on numerous healthy aging outcomes.

In the 1970s, the department had a leadership role in the national cooperative Pooling Project.

In the 1970s, the department had a leadership role in the national cooperative Pooling Project, which pooled data from five prospective epidemiological studies, including PG and WE, and allowed for greater precision when estimating the associations of the major risk factors with CVD. The department took the initiative to organize an International Collaborative Group for cooperative epidemiologic research to clarify some unresolved

issues in chronic disease epidemiology. This endeavor involved colleagues responsible for 15 population studies (including the three in Chicago) in 11 countries (Australia, Denmark, England, Finland, France, Ireland, Italy, Japan, Scotland, Switzerland, and the U.S.), with a combined sample size totaling 52,000 middle-aged men.

Two major studies were carried out by the group, with members of the department playing major leadership roles. The first was a set of analyses involving all the cohorts separately, on the relationship of asymptomatic hyperglycemia at baseline to long-term risk of CHD and cardiovascular, as well as all-cause mortality. The second study used statistical techniques to combine the data from all 15 studies to assess the association of baseline serum cholesterol to long-term risk of cancer. Thirty years later, the Pooling Project and Collaborative Group efforts inspired the Lifetime Risk Pooling Project, led by Donald Lloyd-Jones, which harmonized data on an even broader scale and over longer-term follow up.



In 1981, a joint research program in CVD was initiated between the People's Republic of China and the United States of America under the U.S.A.-P.R.C. Cooperation in Science and Technology. In 1984, cooperation was expanded to include cardiopulmonary disease. This cooperation, under the aegis of the National Heart, Lung, and Blood Institute (NHLBI) on the U.S. side, was focused on cross-sectional and prospective studies of the cardiovascular and cardiopulmonary diseases and their risk factors, based on internationally standardized methods and comparisons between American and Chinese data and trends. It involved 10,076 Chinese men and women ages 35-54 at the initial survey in 1983 at four sites: northern urban (Beijing), northern rural (Beijing), southern urban (Guangzhou) and southern rural (Guangzhou). Jeremiah Stamler served as co-chairman of the U.S. group involved in this endeavor. The study found disparate prevalences of the major risk factors across the populations but very similar relative risk associations with CVD outcomes.

Early Intervention Trials on Major Risk Factors

Once the major risk factors for CVD had been identified, attempts to modify those risk factors followed rapidly. In its first two decades, the department had major leadership responsibilities in national and international cooperative clinical trials, including the Chicago Coronary Prevention Evaluation Program, the National Diet-Heart Study, the Coronary Drug Project, the national cooperative Hypertension Detection and Follow-up Program, the Multiple Risk Factor Intervention Trial, the national cooperative Systolic Hypertension in the Elderly Program, the cooperative Treatment of Mild Hypertension Study, and the national cooperative Dietary Intervention Study in Children. Numerous early faculty and fellows in the department contributed to these early studies on prevention of CVD and its risk factors, including the Stamlers, Kiang Liu, Alan Dyer, David Berkson, Linda Van Horn, and Richard Cooper.

The department's experience in intervention trials includes a long, productive history of dietary intervention trials. Most of these studies involved reducing dietary fat, cholesterol, and sodium intake, with simultaneous increases in complex carbohydrate, fiber, and unsaturated fatty acids. For example, the Coronary Prevention Evaluation Program (CPEP) was a multifactorial trial on the primary prevention of CHD in over 500 high-risk men, the first such research in the world. CPEP was designed to test the lipid-lowering benefits of dietary patterns reduced in total and saturated fat and dietary cholesterol. This study helped to provide the impetus for the landmark MRFIT trial.

Health experts from the People's Republic of China visit Jeremiah Stamler to discuss hypertension. Medical student Greg Kennebeck stands tall as Linda Van Horn and Tony Sporato take his height and weight measurements.



The Multiple Risk Factor Intervention Trial (MRFIT) and Observational Cohort of Screenees



The standardized assessment of health factors demonstrates the rigor of early cohort studies in the department.

Prior to the 1970s, mortality from CVD was at its peak in the U.S., accounting for 42% of deaths. Average blood cholesterol levels were over 220 mg/dL, hypertension was rampant, and smoking was common, especially among men. Stamler and colleagues reported growing evidence that any one of these risk factors was detrimental to health, but risk of cardiovascular mortality rose sharply among those who exhibited all three. A multi-center collaborative randomized clinical trial was needed to achieve the estimated sample size required to determine whether behavioral interventions aimed at reducing these risk factors through dietary changes to lower blood cholesterol, counseling on smoking cessation, and blood pressure management, including medication, could significantly reduce cardiovascular mortality compared to usual care.

In total, MRFIT screened over 356,000 men ages 35-57 to randomize 12,866 men. Those not enrolled, the "screenees," were also followed in an observational study to further support additional hypotheses. Twelve clinical centers were established across the country, and dietitians, behaviorists, and clinicians were engaged in the study effort that continued for over ten years. This study, for which Stamler led the steering committee, was supported by numerous department faculty, and it was one of the first multicenter cardiovascular mega-trials.

Men in MRFIT were randomly assigned either to a special intervention program consisting of steppedcare treatment for hypertension (including use of medications such as chlorthalidone, a diuretic), counseling for cigarette smoking, and dietary advice for lowering blood cholesterol levels, or to their usual sources of health care in the community. In the main outcome report, over an average follow-up period of seven years, risk factor levels declined in both groups, but to a greater degree for the men in the intervention arm. Mortality from CHD was 17.9 deaths per 1,000 in the intervention group and 19.3 per 1,000 in the usual care group. The modest difference between arms was likely attributable to population-level declines in smoking rates coupled with better quality diet, and possible adverse effects of the diuretic medication. Nonetheless, MRFIT was a singular achievement, and subsequent post-hoc analyses did reveal significant risk reductions for nonfatal and fatal CHD and CVD events. The greatest enduring legacy of the MRFIT trial comes from its transition from an intervention study to a longitudinal observational cohort study. The large cohort of screenees was followed for cause-specific mortality for several decades after enrollment. MRFIT was the first study with adequate precision (because of its sample size) to describe a continuous and graded association of higher cholesterol with CHD mortality across the full range of cholesterol values in the population. Subsequent studies demonstrated that these findings persisted across varying lengths of follow up and following statistical adjustment for other established risk factors for CHD.

Observational data from MRFIT prompted the conceptualization that maintenance of "optimal" or "low" CHD risk into mid-life was highly beneficial for CHD prevention, but unfortunately rare among U.S. adults. Among the 356, 222 participants in the MRFIT cohort, low risk was defined as follows: optimal levels of serum cholesterol, systolic and diastolic blood pressure, nonsmoking status, and no history of treatment for diabetes. Only 2% of the men in the MRFIT cohort met these criteria, but only six of these men died from CHD during the six-year follow-up, and the CHD death rate was 87% lower than for the rest of the cohort.

These interesting results, which turned the risk factor concept on its head, were validated and expanded with follow up of the Chicago Heart Association middle-aged cohort, in which only 2% of men and 5% of women had the low risk phenotype based on all six of the following criteria: serum cholesterol lower than 200 mg/dL, systolic blood pressure 120 mm Hg or lower, diastolic blood pressure 80 mm Hg or lower, no smoking, no diabetes, and BMI lower than 25.0. For the CHA and the similarly defined MRFIT low-risk subcohort, the 25- to 30-year CHD mortality rate was lower by 69% to 82% compared with the corresponding rate for all other individuals; the all-cause mortality rate was lower by 52% to 59%; and estimated longevity was greater by 6 to 7 years.

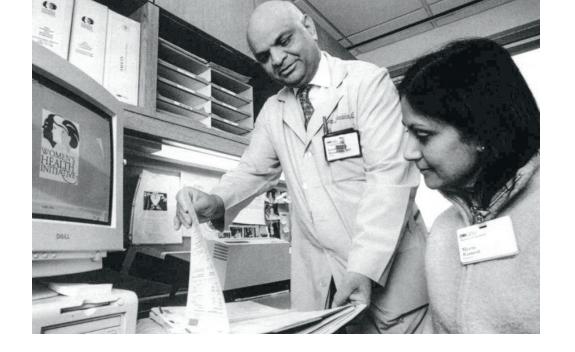
These findings on low risk informed public policy on the strategy for ending the CHD epidemic because maintaining low risk status or striving to get there provided such clear protection against CHD. As Stamler and colleagues wrote, "Data are now extensive regarding what needs to be done. The essentials are derived from a basic law of medicine and public health: epidemics, as originally identified by Virchow in 1953, are due to "disturbances of human culture." First and foremost of these risk factors was identified as "population wide adverse dietary patterns, along with cigarette smoking and sedentary lifestyle at work and leisure." The diets-high in caloric In total, MRFIT screened density, total fat, cholesterol, and saturated and trans fats (from fatand cholesterol-laden red meats, dairy products, egg yolks, visible fats, and commercial baked goods); high in salt and processed sugars; OVer 356,000 men ages 35-57 for some, excessive in alcohol intake; and for all too many, relatively to randomize 12.866 men. inadequate/low in key micro- and macronutrients from vegetables, fruits, whole grains, and legumes (calcium, iron, magnesium, phosphorus, potassium, antioxidant and other vitamins, fiber, vegetable protein, and mono- and polyunsaturated fats)-account for the epidemic occurrences of adverse levels of serum cholesterol, blood pressure, and other metabolic CHD as well as other chronic disease risk factors.

All of these observations also set the stage for decades of work in the department on the low-risk state, which bore fruit in 2010 as the core of the American Heart Association's definition of "ideal cardiovascular health," led by Lloyd-Jones and other major leaders in the field of cardiovascular epidemiology and prevention, including Darwin Labarthe. Labarthe joined the department shortly thereafter, after having been trained by Jeremiah Stamler and having an illustrious career in public health, and being the founding director of the U.S. Centers for Disease Control and Prevention's Division of Heart Disease and Stroke Prevention. The concept of cardiovascular health was updated further by AHA in 2022, again led by Lloyd-Jones and other department faculty.



A participant performs study procedures with a departmental study team member.

A doctor examining data on children's eating patterns with a project coordinator.



Dietary Intervention Study in Children (DISC)

Designed to study initiation of optimal diet in children, rather than waiting for adulthood, the Dietary Intervention Study in Children (DISC) was a multicenter, collaborative, randomized trial in 663 preadolescent boys and girls launched in the mid-1980s and led by Linda Van Horn. Participants had elevated low-density lipoprotein cholesterol, and the study tested the efficacy and safety of a dietary intervention to lower saturated fat and cholesterol intake while also advocating a healthy eating pattern.

The study examined children's self-selected eating patterns and approaches to achieving adherence to the DISC fat-reduced diet intervention with children in the usual-care group. A detailed food-grouping system was developed to indicate "Go" (less atherogenic) foods or "Whoa" (more atherogenic) foods. At the end of the study, differences between the two treatment groups were significant for beneficial changes in consumption of dairy foods, desserts, and fats/oils, with the intervention group reporting a 0.2- to 0.3-serving-per-day greater increase in "Go" foods than the usual-care group. There were also important differences in overall diet quality and snack food choices.

During the later 1980s, under the leadership of Alan Dyer, the department also completed two clinical trials on control of blood pressure by nutritional/lifestyle means. The first was a single site study on the primary prevention of hypertension that involved 201 hypertension-prone young adults ages 30-44, recruited from Chicago industrial organizations to assess ability over five years to prevent rises in blood pressure by control of overweight, high sodium intake, and high alcohol intake and correction of low cardiopulmonary fitness by moderate frequent exercise. Over the five years of follow-up, the incidence of hypertension was significantly lower in the intervention group compared to the control group, at 9% versus 19%.

The second trial was a cooperative effort between the Chicago and Minneapolis Centers of the Hypertension Detection and Follow-up Program following that study's completion; it focused on the control of hypertension by nonpharmacologic means and involved 189 participants with hypertension to determine whether it was possible to control elevated blood pressure in a sizable proportion through skillful and judicious intervention aimed at improving eating and drinking habits, primarily along the lines indicated above. After four years, 39% of intervention participants remained normotensive without use of drugs compared with 5% in the control group.

Early Hypertension Trials

During the 1970s, the department also participated in the Hypertension Detection and Follow-up Program (HDFP), a national cooperative population-based trial on stepped-care antihypertensive drug treatment for reducing mortality among adults with hypertension. It involved screening of over 150,000 people at 14 sites across the country. In Chicago, 10,940 participants were recruited and enrolled under the direction of Jeremiah Stamler and other faculty.

Participants were randomized to stepped-care local clinic management or referral to a specialist. Five-year mortality from all causes was 17% lower for the stepped-care group compared to the referred care group. These findings indicated that the systematic effective management of hypertension had great potential for reducing mortality for the large numbers of people with hypertension, including those with "mild" hypertension.

In the mid-1980s, based on persisting concerns regarding the optimal treatment of "mild" hypertension, especially in relation to cardiac end points, the department took the initiative to launch the multicenter Treatment of Mild Hypertension Study (TOMHS). This double-blind, long-term randomized controlled trial assessed the comparative efficacy of older versus newer antihypertensive drugs in low dosage, combined with nutritional intervention for control of high blood pressure. Middle-aged adults with mild hypertension were randomized at four clinical centers to one of six groups, all receiving long-term nutritional counseling. TOMHS established that drug treatment in combination with nutritional intervention was more effective in preventing cardiovascular and other clinical events than nutritional treatment alone.

The department was also one of the participants, starting in 1984, in the national cooperative Systolic Hypertension in the Elderly Program. This long-term double-blind trial assessed efficacy of low-dose, stepped-care drug treatment (diuretic plus beta blocker or reserpine, as indicated) versus placebo for the prevention of stroke in over 4,000 people ages 60 and over with isolated systolic hypertension. This landmark trial reported a 36% reduction in risk of stroke, as well as significant reductions in heart failure and CHD events, and it shifted the paradigm of treatment from a focus on diastolic blood pressure to elevated systolic blood pressure, which is a far more prevalent issue.

Summary

Thus, the department's early observational studies involving large numbers of participants helped to establish the major risk for CVD (now called "traditional risk factors," but they were not known prior to these studies) and to quantify precisely their associations and prevalence in diverse populations. Once this knowledge had been gained, department investigators pivoted rapidly to lead large intervention trials to prevent progression of risk factors and to alter the natural history of risk factor-disease associations. Through this work, the fields of cardiovascular epidemiology and prevention were firmly established, led by Jeremiah Stamler and his colleagues.



Jeremiah and Rose Stamler, 1985

Department Chairs Over the First 50 Years

JEREMIAH STAMLER, MD FOUNDING CHAIR, 1972-1986

It is impossible to separate the history of the department from the inspiration and legacy of Jeremiah Stamler, his work, and his insights. They continue to power much of the department's philosophy and approach to this day. He, along with his wife Rose, set the tone of observational to translational investigation, collaborative science, methodologic excellence, and impactful dissemination that persist to this day. He lived to see the department's 50th year, passing in early 2022. It is fitting to recognize that Jeremiah's lifelong healthy lifestyle and his intellectual curiosity kept him fully engaged in research until only a few days before his passing, as he was planning manuscripts and grant renewal applications to the end. He is heralded throughout this monograph, and his life and legacy are celebrated in an In Memoriam by Philip Greenland.



ALAN DYER, PHD



Alan Dyer became acting chair in 1986 upon the retirement of Jeremiah Stamler. Notable features of his tenure include the completion of recruitment in the 52 centers participating in INTERSALT, and the analysis and publication of results

related to the primary hypotheses. He assisted recruitment and completion of the baseline, 2-, and 5-year follow-up exams of Chicago participants in the Coronary Artery Risk Development in Young Adults (CARDIA) study. He also completed and published results from two clinical trials on control of blood pressure by nonpharmacologic means. Under his leadership, the department moved from its space in the Morton building on the Chicago campus of Northwestern to 680 N Lake Shore Drive, Suite 1100, including consolidation of its two research clinics (the CARDIA clinic and the department's downtown clinic) in space adjacent to the department.

Preventive Medicine has contributed

PHILIP GREENLAND, MD

PHILIP GREENLAND, MD

Philip Greenland was recruited by Dean Harry Beaty to be the second permanent chair of the department, beginning in 1991. At the time, the department was well-known in cardiovascular epidemiology and included, among the small number

of full-time faculty, emeritus chair Jeremiah Stamler, Rose Stamler, Alan Dyer, Kiang Liu, Linda Van Horn, Joan Chmiel, and Martha Daviglus. The main goals for the department, upon Greenland's arrival, were to recruit additional faculty, broaden the department beyond its primary focus on cardiovascular epidemiology, evaluate the status of the Master's in Public Health (MPH) Program and decide on its future, and to expand the research portfolio. Large research projects that already existed within the department included the INTERSALT Study and the CARDIA Study. It was also important to improve the cardiovascular post-doctoral training program and to successfully renew the longstanding T32 training grant from the National Heart, Lung, and Blood Institute. All of these goals were achieved, and a great deal of growth in size and scope of the department ensued. Greenland also participated actively in growing the medical school's research enterprise, serving as principal investigator on the school's K12 Program (faculty development awards for research) and a K30 Curriculum Development Program in Clinical Research. These research support programs were eventually converted by the NIH into the Clinical and Translational Science Award Program (CTSA), which led to development of the Northwestern University Clinical and Translational Sciences Institute (NUCATS), which Greenland directed initially as executive associate dean for clinical research, starting in 2005. Many of the department's current leaders were recruited during his tenure, including Donald Lloyd-Jones, Mercedes Carnethon, Bonnie Spring, Lifang Hou, Denise Scholtens, and Leah Welty. By the end of his term, there were 25 full-time regular faculty in the department, and the size and scope of the department's research and training activities had expanded considerably.

ROWLAND "BING" CHANG, MD, MPH



When Philip Greenland decided to lead Feinberg's new Clinical and Translational Science Institute, Rowland "Bing" Chang was appointed as interim chair of the department. During his leadership, the focus was on growth of faculty

had been mentored by other leading epidemiologists that were colleagues of Jeremiah Stamler. Having pioneered the methods and approach to examining lifetime risks for CVD at Framingham, Lloyd-Jones brought that perspective to the many cohorts within and linked to the department. His first major grant as PI in 2005 created the Lifetime Risk Pooling Project, which continues to fuel major scientific manuscripts and serve as a platform for methods development to the present. In 2009, Lloyd-Jones, then an associate professor, was appointed the third permanent chair of the department. Under his tenure, the department has seen explosive growth, from approximately 30 to 75 full-time faculty, through recruitment of external experts and internal trainees. This strategic growth has been driven by a desire to diversify the research portfolio to encompass other chronic diseases of aging and the life course more fully; to leverage new biostatistical, data science, and informatics methods; to enhance novel means for deep phenotyping (including omics technologies); and to expand behavioral interventions through use of new technologies and sensors. The growth in the faculty necessitated codifying the division structure in the department and Following Rowland "Bing" Chang, allowed appointment of the first vice chair, Mercedes Linda Van Horn became interim Carnethon, who focuses on faculty mentoring and career chair in 2007. With continued development. It also resulted in more than a tripling in expansion of department research grant award dollars and a major increase in the research activities, faculty, and staff, she impact of the department. Other initiatives have included and department administrator the development of a new faculty track in the medical Andrea Minogue received approval school, the Team Scientist track, to better assess and value the contributions of methodological experts to research projects and education programs across multiple disciplines. From 2012-2020, Lloyd-Jones also led the Northwestern University Clinical and Translational Sciences Institute (NUCATS) before stepping down from that role to become the national president of the American Heart Association.



within the Behavioral Medicine and Biostatistics Divisions. He integrated the newly formed behavioral medicine group, under the direction of Bonnie Spring, into the Northwestern and department ecosystems, which helped lead to successful research and training programs, and further recruitment and development of numerous successful faculty in these areas. For example, David Mohr and Brian Hitsman were recruited during this time. Additionally, there was growth in the Biostatistics Division, especially with the reformulation and establishment of the Biostatistics Collaboration Center, a more appropriate name for what has become a most successful enterprise for the department and the school. Chang stepped down as interim chair of the department to concentrate more time on collaborative research on physical activity in individuals with arthritis, and on his substantial ongoing teaching and clinical responsibilities. LINDA VAN HORN, PHD, RD for, planned, and executed the department's second major move of its physical footprint from the 11th floor to the 14th floor of the 680 building. This move significantly expanded office and communal space for the department and further consolidated the research clinic space in a single suite adjoined to the department on the 14th floor. Van Horn also continued strategic recruitments and oversaw further growth in the Biostatistics Division, setting the stage for the recruitment of the third permanent chair.

DONALD LLOYD-JONES, MD, SCM



Recruited to the department in 2003 from Harvard Medical School and Massachusetts General Hospital by Philip Greenland, Donald Lloyd-Jones was also an active early career investigator at the long-running Framingham Heart Study, where he

Phase 2

Expanding Epidemiology— Early Adult and Midlife Determinants of Chronic Diseases



Modifiable risk factors for heart disease, including blood pressure, received increased attention in the 1980s and were a central focus of cohort studies in early and midlife adults.

HE INITIAL WORK DEFINING THE MAJOR RISK FACTORS FOR CVD (AND OTHER CHRONIC DISEASES OF AGING) WAS PERFORMED LARGELY IN COHORTS OF MIDDLE-AGED INDIVIDUALS FOLLOWED INTO LATER LIFE. Notably, as those cohorts aged, the prevalence of hypertension and dyslipidemia increased markedly, as did susceptibility to hyperglycemia and diabetes. Many questions remained regarding the origins of those risk factors: Were they destined to occur with aging? Or as a result of heredity? Or were there potentially modifiable lifestyle, social, and environmental factors earlier in life, that were upstream of the risk factors, that might serve as targets for prevention of risk factor development? If risk factor development could be avoided in the first place, would that be even more powerful as a prevention strategy for CVD than treating the risk factors once they developed? And, crucially, did the existing risk factors, or their antecedents, possibly explain the marked disparities in health outcomes between individuals who identified as Black and those who identified as white? Beyond these questions, it was also unclear whether there might be additional risk factors or prevention targets yet to be discovered among middle-aged individuals. These critical issues dominated the population science and prevention conversation during this phase of the department's lifespan, and department faculty answered the call by participating in and leading a cadre of new research studies.

The Coronary Artery Risk Development in Young Adults (CARDIA) Study

The CARDIA study was among a suite of studies launched by the National Heart Lung and Blood Institute (NHLBI) during the 1980s. Along with other population-based cohort studies, including the Atherosclerosis Risk in Communities (ARIC) study, the design and launch of CARDIA by NHLBI stemmed directly from the 1978 Bethesda Conference on the Declining Mortality from Coronary Heart Disease.

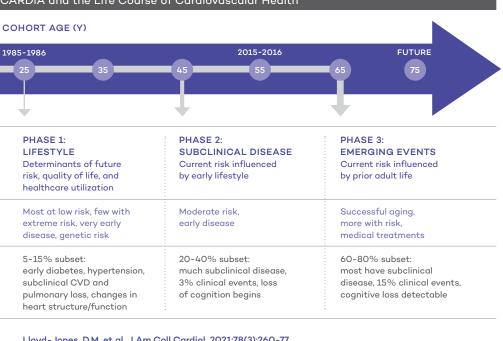
In that seminal conference, leading minds came together to understand the emerging decline in coronary deaths across many countries, define the origins of the decline, and understand disparities in risk factors and outcomes for CHD. CARDIA was unique in that the study objective was to enroll and study young adults before the traditional age of development of heart disease or even of risk factors. When the call came from the NHLBI to identify field centers to conduct this research, the Department of Preventive Medicine was poised to compete for the award, given the department's prior successes in the field of prevention and population-based studies, and its excellence in phenotypic data gathering in epidemiological studies.

Kiang Liu, an assistant professor at the time, laid out an ambitious plan to recruit and enroll over 1,000 adults between the ages of 18 to 30 who self-identified as Black or white and who lived in Chicago. Under his leadership, the application was reviewed favorably, and his team convinced young healthy women and men to join a study about a disease that they did not have-one that was typically thought of as affecting middle-aged and older adults. Against the backdrop of significant life events taking place during young adulthood such as finishing school, starting a first job, and building a family, CARDIA investigators at Chicago and three more centers (in Minneapolis, MN, Birmingham, AL, and Oakland, CA) succeeded in enrolling 5,115 adults in 1985-86. Kiang Liu led the Chicago Field Center of CARDIA until 2013, after which Donald Lloyd-Jones became the principal investigator.



CARDIA and the Life Course of Cardiovascular Health

COHORT AGE (Y)



-15% subset:	20-40% subset:
arly diabetes, hypertension,	much subclinical disease,
ubclinical CVD and	3% clinical events, loss
ulmonary loss, changes in	of cognition begins
eart structure/function	

Lloyd-Jones, D.M. et al. J Am Coll Cardiol. 2021;78(3):260-77. Schematic of the Coronary Artery Risk Development in Young Adults Study (CARDIA) and its contributions to understanding the life course of cardiovascular health and disease. CVD=cardiovascular disease.

Kiang Liu, Linda Van Horn, and Philip Greenland

The CARDIA study filled a unique niche in the portfolio of research at the NHLBI. For the first time, attention was placed on the evolution of cardiovascular health in young adults. CARDIA is one of the longest running cohort studies and has generated multiple insights into the evolution of cardiovascular disease

Jeremiah Stamler exercises in his apartment building in Chicago.



Over more than 35 years of follow up (to date), CARDIA investigators have re-examined participants nine times. Those examinations have yielded tremendous insights into the role of behaviors, social characteristics, neighborhood and environmental factors, psychological factors, and health history on the development of heart disease. The study's contributions have gone beyond the initial plans by leveraging emerging technologies to characterize subclinical disease and molecular markers including the exposome-the interaction of our genes with the environment. Findings from CARDIA, including more than 180 ancillary studies and 1,000 publications, have been disseminated broadly in the scientific and lay literature and have been featured in numerous clinical practice guidelines.

Few studies have lasted as long as CARDIA or yielded as many insights into the evolution of disease, the life course of healthy and unhealthy aging, and strategies for prevention. CARDIA has also served as a rich platform for the development of fellows and junior faculty over generations. Many current department leaders were supported as CARDIA investigators and received major NIH

Few studies have lasted as long as CARDIA or vielded as many insights.

awards as ancillary studies to CARDIA. These additional projects have added tremendous value to the CARDIA database, exploring trends in risk factors with aging using novel methods, understanding the genesis of subclinical CVD and early clinical events, detailing molecular mechanisms of aging, understanding the influence of neighborhood and environmental factors, including those related to structural racism and segregation, on risk factor development and the gene-environment interactions, and much more.

Ongoing work now allows for unique insights into the evolution of the epigenome, transcriptome, proteome, metabolome, and microbiome across multiple time points through young adulthood into midlife. With a continued infusion of new investigators in the department who bring their own innovative insights, the study's contributions are expected to last for decades to come.

International Study of Sodium, Potassium, and Blood Pressure (INTERSALT)

Jeremiah Stamler launched the INTERSALT study in the 1980s to fill gaps in the research on the association of sodium intake and blood pressure. Previous studies lacked valid measures of salt intake or had inadequate sample sizes to detect associations. INTERSALT was the first large-scale international dietary study, with 10,079 men and women ages 20-59 sampled from 52 diverse study sites in 32 countries, with high-quality data collection and analyses. It was supported by the NHLBI (United States), the Wellcome Trust (United Kingdom), and other funding foundations worldwide.

The study found independent and significant positive relations between sodium intake and blood pressure, within and between countries. It also found that alcohol intake was directly associated with blood pressure, while potassium intake was inversely associated. Some of the biological observations regarding the relationships between sodium intake and urinary sodium output, as well as the important variances of intra-individual and inter-individual differences in sodium intake. radically changed the field and approaches to understanding dietary nutrient compositions and how to assess them in healthy individuals.

Four decades have passed, and the landmark findings of the impact of salt on high blood pressure from INTERSALT still echo in dietary recommendations on sodium reduction for management and prevention of high blood pressure by all major scientific, professional, and governmental bodies, such as the U.S. Food and Drug Administration, the U.S. Department of Agriculture (and its dietary guidelines for Americans), the American Heart Association, the American Diabetes Association, and the World Health Organization.

During and after INTERSALT, investigative advances facilitated progress on the longstanding problem of associations of multiple nutrients with blood pressure. Advances included:

Enhanced understanding of the optimal research designs;

Clarification of the role of high dietary salt, high sodium/potassium ratio, inadequate potassium, high body mass, and heavy alcohol use in the population;

Accrual of new data on possible relations of other dietary factors to blood pressure, from the Dietary Approaches to Stop Hypertension (DASH) feeding trials; and

A sharpened definition of methodological considerations to address unresolved aspects of the diet-blood pressure problem.

This latter point about methods indicated what was needed to unravel complex dietary and other influences on blood pressure:

Large population-based samples, preferably with diverse lifestyles;

Collection of high-quality dietary data by methods considering the observed high ratios of intra- to inter-individual variances of nutrient intake, and enabling adjustment for resultant regression-dilution bias;

Control for multiple possible confounding variables;

Standardized quality-controlled data collection methodology; and

Modern methods for data entry, transmission, processing, review, edit, and analysis.

The stage was set for INTERMAP.



A research assistant confirms an appointment with a participant.

International Study of Macro-nutrients and Blood Pressure (INTERMAP)

Following the INTERSALT model, the International Study of Macro-nutrients and Blood Pressure (INTERMAP) was an epidemiological investigation that took place between 1996-1999 to clarify unanswered questions on the role of multiple dietary factors in the etiology of unfavorable blood pressure patterns prevailing for most middle-aged and older individuals. Each of the international samples (China, Japan, United Kingdom, and the U.S.) was representative of a defined population; both general population and workforce samples were included. Ultimately, the international cooperative study recruited 4,680 men and women ages 40–59 from 17 population centers. The study collected a core set of rigorously standardized, high-quality data on diet, urinary sodium, and potassium levels (indicators of dietary intakes), and blood pressure levels across East Asian

> and Western populations consuming diverse diets. It was supported by NHLBI (United States) and other funding agencies in Japan and the UK.

The primary aim of INTERMAP was to advance knowledge on influences of dietary factors on the blood pressure of individuals, and on their role in the etiology of blood pressure in men and women of varied ethnic, racial, and socioeconomic backgrounds. While many dietary correlates of high blood pressure were established based on findings from INTERSALT, INTERMAP sought to elucidate the influences of other dietary factors such as the amount and type of protein (including specific amino acids), lipids (including specific fatty



Jeremiah Stamler surrounded by foods high in salt and fat

acids), carbohydrates (including fiber), and dietary calcium, magnesium, iron, selenium, vitamins, caffeine, and other nutrients of interest. Another aim, that remains a current priority in nutrition research, was to explore relations of food groups (fish, lean red meat, low-fat dairy products, fruits, and vegetables) on blood pressure. INTERMAP was also ahead of its time in exploring the contribution of social determinants of health, such as education, on blood pressure levels. With its rigorously standardized and high quality-controlled data and large, internationally diverse sample, INTERMAP will continue to shape and influence studies on nutrition and health outcomes.

To date, INTERMAP has generated over 50 publications elucidating associations between diet, metabolism, and blood pressure. In addition to salt intake, numerous dietary factors associated with blood pressure have been identified. For example, vegetable protein, fruits, fiber, and total n-3 fatty acid are favorable, while sugars and sugar-sweetened beverages are unfavorable for blood pressure. Moreover, the study confirmed specific diet styles that may lower blood pressure, such as the Optimal Macronutrient Intake Trial for Heart Health (OMNIHEART)-style diet and the Dietary Approaches to Stop Hypertension (DASH). These findings support current dietary recommendations on comprehensive nutritional/lifestyle approaches for preventing and controlling high blood pressure as well as related adverse health outcomes.

Recently, INTERMAP investigators have expanded the study's focus to novel areas, including metabolomics: discovery of how known urinary metabolites and associated metabolic pathways underlie relationships of individual dietary factors and nutrients with blood pressure. The study is also validating these metabolites and metabolic pathways with data from several ongoing prospective studies in the department. The combined use of these unique trial, nutritional, and metabolomic data, with the application of both discovery and validation, is shedding new light on both the adverse impact of sodium intake and the beneficial impact of DASH/OmniHeart-like diets on blood pressure.

Led by Jeremiah and Rose Stamler, with Linda Van Horn, Kiang Liu, and Alan Dyer providing methodological expertise, INTERMAP became widely hailed as one of the most rigorously performed dietary studies ever, and it has influenced dietary guidelines for decades.



The Women's Health Initiative (WHI)

The Women's Health Initiative (WHI) is a large, ongoing longitudinal study designed to investigate strategies for the prevention and control of common chronic diseases in postmenopausal women, including CVD, cancer, and osteoporotic fractures.

The WHI consisted of three overlapping clinical trials of hormone therapy, diet modification to reduce total dietary fat, and calcium/vitamin D supplementation. Women who did not participate in the hormone therapy or diet modification trials were invited to participate in the observational study. Women were recruited into WHI from 1993 to 1998 at 40 U.S. clinical centers, including a Chicago Vanguard Center led by Philip Greenland, Linda Van Horn, and Kiang Liu. WHI enrolled 26,046 women from under-represented groups and 135,762 white women from across the U.S. in the various arms of the study. After the main study ended in 2005, women were invited to continue follow-up for exposures and outcomes through two extensions to 2020.

The seminal results of the hormone trials changed the paradigm of practice for post-menopausal hormone replacement therapy instantly. Whereas some observational studies had suggested benefit for hormone-replacement therapy in reducing risk for CHD in post-menopausal women, the WHI hormone studies demonstrated neutral to harmful effects for CHD, stroke, pulmonary embolism, dementia, and an array of other chronic diseases that more than offset modest benefits in post-menopausal symptoms and bone loss. Ongoing follow up has revealed even more nuanced findings, with possible greater benefits among 50-59 year-old women compared with older women, perpetuating the scientific debates around hormone replacement therapy. The dietary intervention, which targeted a low-fat diet with increases in fruits and vegetables and whole grains versus usual diet, resulted in modest improvements in dietary patterns and non-significant reductions in invasive breast cancer and CVD. Nonetheless, the large and diverse study sample has allowed for significant insights into chronic diseases of aging among a diverse cohort of older women.

Summary

As this phase of departmental focus evolved into the next, the early patterns persisted. Vexing and deeply important questions about risk factors for human disease were thought about, addressed with thoughtfully designed studies, and pursued with rigor. As a result, the major research projects for this phase, as with the first phase, have continued to support scientific investigation and insights and young investigators' new ideas for decades after their initial establishment.

WHI staff, including Shirlee Mohiuddin and Eileen Vincent, who still work in the department



A WHI participant receives a WHI pin and bottle of hormone replacement therapy study pills from a nurse.

Phase 3

Expanding the Toolbox for Epidemiology, Analytics of Human Health, and Prevention of Disease





Kiang Liu was the prinicipal investigator for the MESA study.

Top: Ivy Wong, a research project coordinator, conducts a walking test with a study participant.

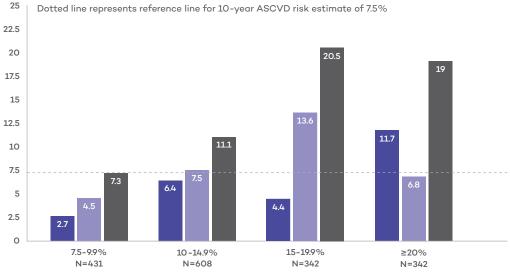
T THE BEGINNING OF THE 21ST CENTURY, THE FIELDS CONTRIBUTING TO POPULATION SCIENCE AND PREVENTION WERE EVOLVING RAPIDLY. Emerging technological advances in deeper phenotyping of preclinical disease states (with imaging and biomarkers), in genomics (as a result of the Human Genome Project), and in big data were looming, as were novel technologies to measure and intervene on human health behaviors. These advances drove significant growth and diversification of the faculty in terms of the types of expertise and research skills needed and promised exciting new possibilities in the next phase of the department's growth.

The Multi-Ethnic Study of Atherosclerosis (MESA)

Given ongoing questions about the origins of health disparities across racial/ethnic groups in the U.S., and the availability of novel means for detecting the presence and progression of preclinical cardiovascular disease in humans, the NHLBI initiated the MESA Study in July 2000. Northwestern investigators led by Kiang Liu successfully competed to become one of the six field centers across the U.S. He led the field center until Norrina Allen became the PI at the time of the 6th examination cycle in 2016.

The major goals were to investigate the prevalence, correlates, and progression of subclinical CVD in a population-based sample men and women aged 45-84 years. In the end, 6,814 participants were enrolled, among them 38% who identified as white, 28% as African-American, 23% as Hispanic, and 11% as Asian (of Chinese descent). Baseline measurements include measurement of coronary artery

ASCVD Rate Among MESA Participants without Diabetes by CAC Burden and Estimated ASCVD Risk



calcium (CAC) using computed tomography; measurement of ventricular mass and function using cardiac magnetic resonance imaging; measurement of flow-mediated brachial artery endothelial vasodilation (FMD), carotid intimal-medial wall thickness (IMT), and distensibility of the carotid arteries using ultrasonography; measurement of peripheral vascular disease using ankle and brachial blood pressures; electrocardiography; and assessments of microalbuminuria, standard CVD risk factors, sociodemographic factors, life habits, and psychosocial factors. Initially planned as an 8-year study, MESA has been renewed and completed six examination cycles, with the seventh examination starting in 2022.

The most important contributions of MESA have been in the arena of subclinical disease imaging. Over time, MESA, including department investigators, has provided the essential data that led national and international clinical practice guidelines on prevention of CVD to recommend incorporation of CAC measurement into decisionmaking for initiation of statin medications, when traditional risk factors and risk scores yielded intermediate or indeterminate results. CAC scores have consistently been shown to reclassify risk, upward and downward, more correctly than any other test. At the same time, some promising imaging approaches, such as carotid IMT and brachial artery FMD, have not been shown to be useful as routine or targeted clinical measures for baseline or progression. Kiang Liu, Philip Greenland, Donald Lloyd-Jones, Norrina Allen and a host of other department faculty and trainees have leveraged these data to advance the science of risk prediction and create novel insights into the development and progression of atherosclerosis and left ventricular remodeling.

Other studies have used the extensive amount of core data and data from hundreds of ancillary studies to examine serum biomarkers and their associations with disease. Whereas many biomarkers related to inflammation and novel lipid phenotypes have been associated significantly with CVD risk, those that provide insight into existing target organ damage, such as natriuretic peptides and high-sensitivity cardiac troponin measures, as well as measures of renal dysfunction have shown the greatest promise in improving discrimination and reclassification of risk.

Nasir et al., MESA Study, JACC 2015



Computed tomography photograph of coronary artery calcium

LEGEND:

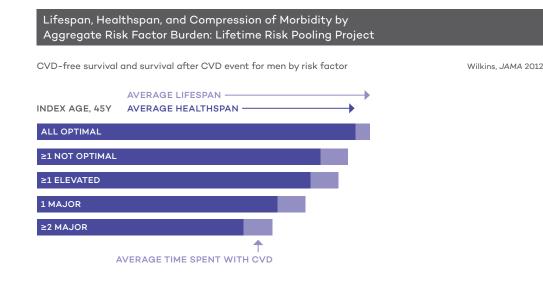
Dark Purple = 0 CAC; Light Purple = CAC 1 to 100; Grey = CAC>100.

The lowest ASCVD event rates per 1,000 persons (Y-Axis) are among those with 0 CAC (Purple) at every level of Estimated 10-Year Risk Category (X-Axis) in 1,822 adults free from diabetes in MESA

The Lifetime Risk Pooling Project (LRPP)

In 2005, with funding from the NHLBI, Donald Lloyd-Jones initiated the Lifetime Risk Pooling Project to recapitulate the prior U.S. Pooling Project of the 1970s, but to update the focus to understand longer-term and lifetime risks for CVD and other chronic diseases, and to provide insight into competing risks for diverse outcomes between racial and ethnic groups. The department's involvement in many longstanding population-based cohorts (Western Electric, People's Gas, CHA, MRFIT screenees, CARDIA, MESA, and more), and the availability of de-identified datasets from many other long-term U.S.-based cohort studies from Puerto Rico to Hawaii, catalyzed a new era of big data harmonization that has been copied by many other institutions and projects since. By 2020, under the leadership of John Wilkins, the LRPP and its ancillaries contained data on more than 630,000 individuals followed for more than 12 million person-years.

Men who have a greater number of optimal levels of blood pressure, smoking status, lipids, glycemic status (diabetes), and have a longer lifespan with fewer years lived with CVD.



From that beginning, the LRPP has published seminal results on physiologic and lifestyle risk factor associations with lifetime risks for CVD, cancer, and other diseases in high-profile journals, and pioneered methods in describing competing risks, compression of morbidity, lifespan and healthspan assessment, health disparities, and more in nearly 50 publications to date. New long-term and lifetime risk scores developed in the robust LRPP data have changed the paradigm of risk assessment in national and international prevention guidelines. This big data platform has also served as a useful tool for funded projects in development of novel analytic methods related to survival analysis, competing risk, dynamic risk prediction, machine learning, and precision medicine risk assessment by biostatistical and other faculty, including Juned Siddique and Lihui Zhao.



Growth of Biostatistics and Expanding Quantitative Methodology

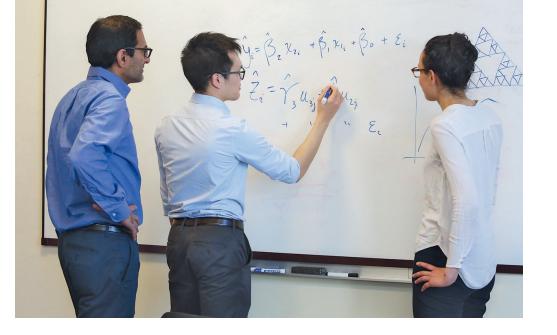
Close engagement of biostatisticians and content experts from the outset of a project has always been a hallmark of the department's approach to the leadership and conduct of large-scale cohort studies and clinical trials. Since the inception of the department, biostatistics expertise has been critical for study design, rigorous data analysis, and interpretation of study findings that have informed clinical and public health practice for decades. Intra-departmental collaborations on landmark studies including the CHA cohort, INTERMAP, CARDIA, and MESA provided the genesis for a growing cadre of biostatisticians, with a small but mighty group of faculty and staff members bringing specific statistical expertise to these and many other teams. With formal designation as a division within the department starting in 2007, the Division of Biostatistics has grown into a robust group of over 50 faculty and staff with a notable national and international reputation and scientific impact.

Excellence in the collaborative practice of biostatistics continues to be a driving force behind the day-to-day work of all members of the Division of Biostatistics. Establishment of the Cancer Center Biostatistics Core in the 1990s catalyzed effective routes for initiating and sustaining collaborative partnerships between biostatisticians and cancer researchers within Feinberg. The expansion of core-based activities to include the Biostatistics Collaboration Center in 2006 for projects not related to cancer, and later the unification of cancer biostatistics, bioinformatics, and clinical informatics under the Lurie Cancer Center Quantitative Data Sciences Core, firmly established the department's biostatisticians under a centralized academic home in the division, with administrative structures for effectively supporting ongoing work.

Biostatistics Collaboration Center faculty and staff, 2019



Leah Welty, Director of the Biostatistics Collaboration Center Biostatistical learning is an interactive process as demonstrated by this meeting led by Juned Siddique with junior collaborators Alan Kuang and Nicola Lancki.



Collaborative biostatistical activities led by department faculty thrive in other discipline-specific areas across Northwestern, including at the Mesulam Center for Cognitive Neurology and Alzheimer's Disease, the Bluhm Cardiovascular Institute, the Comprehensive Transplant Center, and many more divisions, departments, centers, and institutes. Most recently, the launch of the Northwestern University Data Analysis and Coordinating Center (NUDACC) in 2019 brought together and enhanced the infrastructure capabilities and intellectual expertise for the conduct of complex, multicenter clinical trials and observational studies. It also introduced a new group of team members with project management and regulatory expertise who work closely with statisticians for conduct of these studies.

Statistical methodologic enhancements from Northwestern biostatisticians continue to abound in the context of truly synergistic cross-disciplinary partnerships. Noted methodologic strengths within the division, contributed by targeted recruitments of new faculty and growth in skills in existing faculty include longitudinal methods, survival data analysis, handling of missing data, causal inference, network data methods, Bayesian statistics, replication methods, clinical trial design and randomization, cluster randomized trial designs, observational data modeling, semiparametric methods, statistical genetics, data misclassification, meta-analysis, integrated omics, personalized medicine, deep learning, and machine learning techniques. Northwestern biostatisticians also pride themselves on state-of-the art approaches to practice, including implementation of a suite of reproducible research strategies for data analysis and multiple publicly available R packages and R Shiny apps.

The rapid growth of the division, which in 2022 counts 22 full-time regular faculty, has been facilitated by a number of conscious departmental and Feinberg strategies, including: the desire to maintain all biostatisticians at Feinberg together within the division; the deployment of rapid means for recruiting new biostatistical faculty as the Feinberg research enterprise grew substantially in size and scope from 2010 to the present; and the creation and successful evolution of the Team Scientist regular faculty track to reward the critical contributions of biostatisticians to numerous research programs.

Growth of biostatistics research and collaborations also motivated intentional investment in the training and education of biostatistics graduate students. The Master of Science in Biostatistics program emerged in 2016 as a stand-alone program after its beginnings roughly a decade earlier in the combined Master of Science in Epidemiology and Biostatistics degree. The shift to focus on biostatistics exclusively mirrored the rapid emergence of data science worldwide and the need for critical scientific staff roles on biostatistics and health research teams. Beginning in fall 2022, the Division of Biostatistics faculty are excited to welcome their first biostatistics doctoral (PhD) students to campus, ushering in a new wave of possibilities for methodologic innovation.

Northwestern's Division of Biostatistics is a national force, with faculty holding highly visible leadership roles in the American Statistical Association, International Biometric Society, Society for Clinical Trials, Association of Clinical and Translational Statisticians, Caucus of Women in Statistics, and the Biostatistics, Epidemiology and Research Design – Special Interest Group for the Association for Clinical and Translational Science. National Institutes of Health study section panels and study groups requiring data and safety monitoring boards routinely call upon Northwestern biostatisticians for their expertise and guidance.

Informatics and Data Science

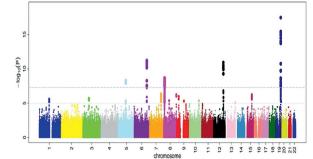
Advances in detailed measurement of complex human health phenotypes, electronic health record (EHR) data, genomics, and a host of other areas led to an explosion in big data and the emergence of new fields to manage and analyze it: informatics and data science. The issues around big data are often summarized by its five essential characteristics: velocity, volume, value, variety, and veracity. In response to these issues, a number of landmark occurrences have highlighted the department's and Feinberg's progress in the big data era.

In the late 2000s, faculty member Warren Kibbe started the Northwestern University Biomedical Informatics Center (NUBIC), which was closely aligned with the Lurie Cancer Center, and began to create the infrastructure for managing data in the Northwestern Memorial Healthcare and Feinberg research enterprises. Catalyzed by the Clinical and Translational Sciences Award (CTSA) led by Philip Greenland in 2008, the NUCATS Institute was created and housed NUBIC and other research-enhancing infrastructure that bridged the health system and the medical school.

A critical decision that catalyzed research was the creation of the Northwestern Medicine Enterprise Data Warehouse (NMEDW) and the inclusion of all data generated in the health system within this highly secure repository, including all EHR, scheduling, revenue, pathologic, laboratory, imaging, procedure-related and other data, and the ability for researchers to house and link research data, including genomic data, alongside them. The firstgeneration NMEDW quickly became a national exemplar for such data warehouses and facilitated Northwestern's selection as a founding member of the eMERGE Consortium that continues to make insights into the use of EHR data and genetic data in clinical practice, and is now co-led by department faculty such as Laura Rasmussen-Torvik and Yuan Luo. With the upgrade of the NMEDW in 2019, it remains at the forefront, with data on over 6.4 million unique patients and inclusion of analytic and visualization tools that enhance research. Numerous fellows and junior faculty within the department, and others across Feinberg mentored by senior faculty (Matt Feinstein, Jane Wilcox, Lisa VanWagner), have leveraged the NMEDW to create funded research platforms to launch their investigational careers.

A critical decision that catalyzed research was the creation of the Northwestern Medicine Enterprise Data Warehouse.





A bioinformatics tool allows for visualization of genetic associations with multiple disease outcomes.

Top: Cathelin Huang, a research project coordinator, and Yeunook Bae, a postdoctoral scholar, prepare to analyze dried blood spot samples using adductomics. Recognizing the need for strategic growth in in informatics, Feinberg recruited Justin Starren in 2011, and he founded the new Division of Health and Biomedical Informatics (HBMI) in the department. Subsequent faculty recruitments within the division and those in other departments that have secondary appointments in the division have driven critical growth in all areas of informatics across Northwestern. Key departmental recruits included Nick Soulakis in public health informatics, Firas Wehbe in research data infrastructure and development of an enterprise-wide clinical research data system, Yuan Luo in data science and machine learning, and Kristi Holmes, who transformed the Galter Health Sciences Library into a

powerhouse in information technology, data repository methods, and assessment of research impact, among others. These faculty have led and provided key collaborative work on scores of cutting-edge research projects across Northwestern with big data and data science areas of focus.

As the fields of informatics and data science have progressed rapidly, the department and school's organizational structures have also evolved, under the leadership of Starren and in close collaboration with the NUCATS Institute, for which he serves as deputy director. NUBIC became the NUCATS Center for Data Science and Informatics in 2015, then evolved further into the Center for Biomedical Informatics and Data Science housed jointly within NUCATS and the newly-created Institute for Augmented Intelligence in Medicine in 2020.

Faculty in the Division of Health and Biomedical Informatics have also played a key role in educating and training the next generation of informaticians and data scientists. In 2011, Starren started the HBMI track within the Driskill Graduate PhD Program, followed by a Master's in HBMI in 2013, a funded Biomedical Data to Knowledge (BD2K) training program in 2016, and a clinical informatics fellowship in 2021.

Molecular Epidemiology

In the early 2000s, genetic analyses were increasingly integrated into the many large observational studies conducted in the department, usually as relatively small so-called "candidate gene" studies which examined a handful of single nucleotide polymorphisms (SNPs) in 1-10 genes selected because previous information had linked the gene to traits of interest.

After the first genome-wide association study (GWAS) was published in 2005, the field of genetic epidemiology experienced a rapid period of data generation: by 2008, GWAS data were generated in the MESA and CARDIA studies, permitting department researchers to easily investigate SNPs of interest in any gene, conduct their own genome-wide analyses, and participate as critical partners in the large GWAS consortia that identified, in some cases, hundreds of novel genetic associations with common chronic diseases and related traits. In the same timeframe, GWAS data were also generated on some participants of the Northwestern NUgene biobank, allowing department investigators to examine interesting associations initially identified in observational studies with genetic association studies using the rich data available on patients in the Northwestern Enterprise Data Warehouse. GWAS data generation in the Hispanic Community Health Study/Study of Latinos (HCHS/SOL), and access to publicly available GWAS datasets like the UK biobank, further increased the numerous GWAS resources being used by researchers in the department. The recruitment in 2010 of Laura Rasmussen-Torvik, and later of Marilyn Cornelis, catalyzed many such studies and set the stage for more sophisticated population-based and clinically based studies.

Much was learned about common genetic variants associated with common diseases from GWAS studies, but these datasets did not include information on rare genetic variants, which appear to account for the majority of phenotypic variation and disease risk. As sequencing costs rapidly declined after 2010, the field of genetic epidemiology transitioned from GWAS studies to exome and whole-genome sequencing studies. With the recent whole-genome sequencing of many MESA and CARDIA participants as part of the NHLBI TOPMed consortium, department investigators are starting to examine associations of rarer variants, individually and cumulatively with common diseases.

While genotyping technologies were rapidly advancing, technologies to enable large-scale assessment of DNA modifications (such as epigenetic methylation), as well as RNA and proteins, were also rapidly advancing. Taking advantage of this new technology, department investigators have led efforts to generate epigenetic data across multiple time points in the CARDIA study and have worked with other epidemiology researchers at Northwestern and across the globe to organize and fund generation of transcriptomic, proteomic, and metabolomic data as part of NHLBI's TOPMed and multiple other consortia. The unique resource of having multi-omic data from thousands of the same individuals at multiple time points across young adulthood is providing important new insights into gene-environment interactions and biologic aging. The epigenome appears to be a key mechanism that is dynamic in response to upstream health behaviors (diet, physical activity, smoking) and environmental exposures (air pollution), links those exposures at the molecular level to gene expression patterns and biological aging, and appears to mediate development of early disease phenotypes. The next frontier of genetic and molecular epidemiology is the combination of multiple types of these data in pan-omic analysis. With expertise in the generation and analysis of pan-omic data and access to pan-omic data from a large number of epidemiologic, trial, and clinical databases, the department is exceptionally well-positioned for this next stage of population health research, led by faculty such as Lifang Hou, Yinan Zheng, Brian Joyce, John Wilkins, Kiarri Kershaw, and many others.



Postdoctoral scholar Nathan Montgomery retrieves stored biospecimens from the -80 degree freezer.

Additional novel methodological strengths at Northwestern, including "top-down proteomics" and "adductomics," are providing new mechanistic insights linking environmental and behavioral exposures to post-translational modifications of proteins that significantly affect the activity and function of those proteins and affect human health. These promising areas, led by faculty members John Wilkins and William Funk, are at the cutting edge of the field of proteomics.

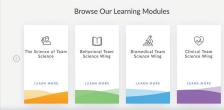
Ongoing work is also leveraging the biorepositories created by long-term department studies, like INTERMAP, to examine the metabolome—the full array of small molecules in blood and urine—that reflect diet, environmental exposures, and physiologic/metabolic processes. This exciting work promises further insights into gene-environment interactions and mechanisms of aging, health, and disease.

Behavioral Intervention Studies

By the early 2000s, the department's reputation and direction was firmly established in the science of CVD prevention. Simultaneously, there was a growing obesity epidemic and with it the recognition of its role in the etiology of chronic diseases such as CVD and cancer.

With an increased interest in behavioral interventions and burgeoning opportunities for funding in the area, the department actively recruited behavioral medicine scientists. In 2005, Bonnie Spring joined the department as professor and eventually chief of a newly created Division of Behavioral Medicine. Shortly thereafter, she received a five-year training grant to develop evidence-based





The COALESCE online training platform, now known as TeamScience.net behavioral practice tools and soon recruited David Mohr, an expert in the design of digital mental health treatments. The division would go on to become well known for its science in mobile health (mHealth) and excellence in the conduct of rigorous clinical trials.

Within the following decade, behavioral medicine saw an increase in activity and reputation in the prevention sciences. At a national level, clinical reimbursement was authorized for the National Diabetes Prevention Program, an intensive lifestyle intervention program to help people lose weight and prevent the onset of diabetes, and the United States Preventive Services Task Force supported intensive multi-component behavioral counseling for obesity based on evidence of efficacy.

In 2007, Spring became the president of the Society of Behavioral Medicine, the preeminent academic society for behavioral science. Shortly thereafter, the department became home to the Society's second journal, *Translational Behavioral Medicine: Practice, Policy, Research,* under Spring's editorship. Around the same

time, mHealth technologies were becoming more central to behavioral medicine science, and both Spring and Mohr were at the forefront of those scientific endeavors. In 2011, Mohr became the director of the Center for Behavior Intervention Technologies (CBITS), which became an NIMH ALACRITY Center in 2020. These early accomplishments effectively put the Department of Preventive Medicine on the map as a central hub of behavioral medicine.

Owing to the increased acknowledgement that human behavior is complicated and that tough scientific problems require a team-based approach, team science became a core scientific and training endeavor in the division. In 2011, Northwestern University's Clinical and Translational Sciences Institute (NUCATS) developed COALESCE, led by Spring, as an online training platform to advance the principles of team science that is still used across the CTSA consortium over a decade later.



As team science has now become a flagship program, the division has also practiced much of what it preaches. Since its inception, the division has grown to include expertise across several areas of health behaviors such as smoking and nicotine addiction (Brian Hitsman), physical activity (Siobhan Phillips), and patterns of eating (Nabil Alshurafa). With the recruitment of Alshurafa, a computer scientist by training, the department was one of the first to house faculty doubly appointed in an engineering department to enhance transdisciplinary science.

As a further testament to its dedication to working across scientific silos, the division is also known for its tight connection to the Lurie Cancer Center. Led by Spring, the division has collaborated on a T32 training grant, Behavioral and Psychosocial Research Training Program in Cancer Prevention and Control, since 2015 and more recently received NCI funding for its STELLAR Center, focused on translating health behavior promotion interventions into cancer treatment and survivorship practice. Mohr also leads a T32-funded Multidisciplinary Training Program in Digital Mental Health. Present and future work in both the ALACRITY and STELLAR centers means the Division of Behavioral Medicine is poised to become well known not only for excellent intervention science, but also for implementing interventions within healthcare systems to get behavioral and mental health interventions into the hands of the people who need them. Thus, the division has stayed at the forefront of translating prevention research into practice while maintaining its cutting-edge in mobile health technologies to improve reach and sustainability of interventions.

Summary

In this third phase of the department's life, the growth in novel technologies and research tools to understand human health catalyzed entirely new areas of exploration within the department and necessitated the recruitment of new generations of faculty, development of new research infrastructure, and definition of novel means for measuring and intervening to promote health and prevent disease. The explosion of big data and analytics opened up new avenues for innovative research programs and created the ability to re-examine existing data in novel ways. Department faculty expanded their collaborations dramatically across Feinberg, Northwestern, and the globe through the creation of new centers and institutes allied with the department's mission.

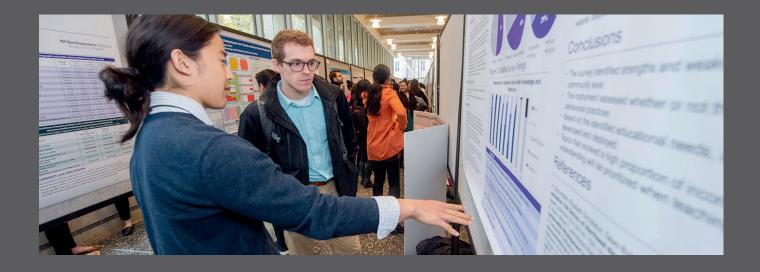


Above: Leveraging the popularity of mobile technologies to measure and promote health.

Left: Payton Solk, research staff, measures the flexibility of a participant.

Institutes, Centers, and Cores





THE INSTITUTE FOR PUBLIC HEALTH AND MEDICINE

Two of the 16 centers in IPHAM are led by Preventive Medicine faculty:

Center for Behavior and Health

Center for Epidemiology and Population Health

Beginning as a faculty member in the Department of

Preventive Medicine in 1995, Rowland "Bing" Chang observed the incredible successes of department faculty in securing federal funds for ongoing epidemiologic studies primarily focused on CVD prevention. He quickly recognized that the secret sauce for success was the collaborative nature of the research in which each collaborator brought their expertise to the research endeavor, creating a whole that was truly greater than the sum of its parts. As a clinician who successfully grew the department's Program in Public Health, Chang was well positioned to understand the critical interplay of public health and medicine, and the importance of aligning these two disciplines within a medical school to enhance education, training, research, and implementation to promote human health. Accordingly, Chang was appointed as the founding director of the Institute of Public Health and Medicine (IPHAM) by Dean Eric Neilson in 2012. The collaborative culture of the department served as an organizing principle for the new IPHAM, which was charged with promoting research and education pertaining to public health and spanning all populations and disease groups. From its inception, faculty from the Department of Preventive Medicine along with the

Department of Medical Social Sciences have formed the core of IPHAM, contributing the key methodological, translational, and collaborative glue that drive successful scientific clinical and public health research. IPHAM serves as a convening space where clinicians, quantitative health scientists, and public health practitioners come together to advance human health and train future generations of researchers and practitioners. Collectively, these ingredients have succeeded in making Feinberg a notable institution in public health research and education nationally.

"IPHAM has been the catalyst for the extraordinary growth in NU-FSM's "dry-lab" (non-laboratory based) research these past 10 years."

ROWLAND "BING" CHANG, MD, MPH FOUNDING DIRECTOR, IPHAM



Bonnie Spring, Director, Center for Behavior & Health (middle)

CENTER FOR BEHAVIOR AND HEALTH

The Center for Behavior and Health (CBH) launched in 2012 as a founding center of Feinberg's Institute for Public Health and Medicine. The center's vision is to leverage behavior's pivotal role in preserving and restoring health through proven behavioral science. In its first decade, CBH's multispecialty investigators launched a robust portfolio of NIH-funded research on determinants and tailored interventions for the major chronic disease behavioral risk factors (smoking, physical inactivity, obesity, poor quality diet, unprotected sun exposure). Interventions developed by CBH scientists integrate novel technologies, including web-based and smartphone-based applications, often combined with human curation and coaching, that increase treatment access, reduce burden, and deliver interventions remotely and efficiently when they are most needed. Increasingly, the center focuses on opportunities to refine and implement these health promotion interventions sustainably in collaboration with health care delivery systems and community-based organizations.



CEPH faculty and staff, 2019

CENTER FOR EPIDEMIOLOGY AND POPULATION HEALTH

The Center for Epidemiology and Population Health (CEPH) was one of the inaugural centers within the Institute for Public Health and Medicine (IPHAM) and was Initially led by Phillip Greenland, former chair of the Department of Preventive Medicine. In 2019, Norrina Allen became the director. The center's mission is to catalyze innovative, high-impact research on the prevention and treatment of diseases and to translate these findings into measurable improvements in health across the life course. Taken together, its three research programs serve as a central hub for research involving innovative new data sources, linking diverse data, pooling and harmonization as well as research on social determinants of health. The center promotes the development and enhancement of largescale research programs that build upon the diverse expertise of our members. By creating interdisciplinary teams, harnessing state-of-the-art technical and methodological advances and integrating novel data resources, CEPH serves to strengthen the translation of clinical questions into high-impact research.



Biostatistics Collaboration Center faculty and staff, 2022

BIOSTATISTICS COLLABORATION CENTER

The mission of the Biostatistics Collaboration Center (BCC) is to support Feinberg investigators as they conduct high quality, innovative health-related research by providing expertise in biostatistics, statistical programming, and data management. The BCC was founded in June 2004 after the Dean's Research Council and the department identified the need for centralized biostatistics resources to address the increasing complexity and quantity of health-related data in medical research. The BCC now consists of eleven faculty biostatisticians, nine master's level biostatistics staff, a financial administrator, and assistant research administrator. They collaborate annually with more than 400 investigators in over 30 departments, divisions, and centers across Northwestern's Chicago and Evanston campuses. Faculty and staff affiliated with the BCC partner closely with their colleagues in QDSC, NUDACC, and the broader Division of Biostatistics.

CENTER FOR GLOBAL ONCOLOGY IN THE HAVEY INSTITUTE FOR GLOBAL HEALTH

The Center for Global Oncology was created in 2021 as part of Northwestern's Robert J. Havey, MD Institute for Global Health. Expanding from the research scope of the Division of Cancer Epidemiology and Prevention, the center has launched an ambitious research program to study cancers—in particular, infection-associated cancers such as those related to human papilloma virus (HPV) and human immunodeficiency virus (HIV). The center works in partnership with investigators in low- and middle-income countries, with the aim of bringing



Lifang Hou, Director, Center for Global Oncology in the Havey Institute for Global Health (middle)

the findings back to the U.S. population to create powerful and cost-effective studies of early-stage molecular changes in diverse cancer patients. The ultimate goal is to use both traditional and novel "omic" technologies, cutting-edge data science, and implementation science to develop and deploy tools for cancer screening and early detection. The center catalyzes the integration of novel molecular biomarkers with data on lifestyle, environmental factors, and social determinants of health to provide new insight into the role of socio-environmental factors in cancer risk, prevention, and disparities.

CENTER FOR BEHAVIORAL INTERVENTION TECHNOLOGIES

The Center for Behavioral Intervention Technologies (CBITs) was founded in 2011 with a National Institute of Mental Health Center grant and support from the department and Feinberg. CBITs conducted early formative research, harnessing digital technologies—including websites, smartphones, networked sensors, and natural language processing—to provide support and treatment to people with common mental health problems such as depression and anxiety. Under the leadership of David Mohr, CBITs has grown from three to eight core faculty members spanning the department, Medical Social Sciences, Psychiatry, and Computer Science. The field has matured from a small research area to a growing industry deploying digital mental health services in large healthcare systems. CBITs' research has similarly matured and expanded; faculty continue to conduct to basic research to understand how to design effective digital tools for a broad range of populations and have extended their work to learn how to implement digital services in healthcare and community organizations.

NORTHWESTERN UNIVERSITY DATA ANALYSIS AND COORDINATING CENTER

The Northwestern University Data Analysis and Coordinating Center (NUDACC) launched in September 2019 to formalize and streamline efforts across the Feinberg School of Medicine to engage in collaborative leadership and oversight of largescale, multicenter, prospective human research studies. The formation of NUDACC represented the culmination of nearly two decades of targeted growth in biostatistical expertise, clinical trial design and conduct, and data management capabilities within the Division of Biostatistics. Led by its founding director, Denise Scholtens, NUDACC partners with clinical and population health principal investigators both within Feinberg and outside the institution to harmonize the research life cycle. Throughout the processes of study design, development of procedures, data procurement, final statistical analyses, and results dissemination, NUDACC emphasizes rigor, efficiency, and close teamwork. In under three years, NUDACC rapidly expanded from the core launch team of four individuals in 2019 to a team over 20 statisticians, project managers, and regulatory experts with more than a dozen large-scale funded projects in 2022. For example, NUDACC serves as the coordinating center (Jody Ciolino, PI) for a large National Institute of Diabetes, Digestive and Kidney Disease (NIDDK)-funded multicenter network focused on cohort studies and clinical trials addressing prevention of cirrhosis and chronic liver diseases. Scholtens is MPI, along with Sanjiv Shah in Feinberg's Division of Cardiology, of the coordinating center for a large new NHLBI-funded multicenter network that will elucidate the phenotypes, mechanisms, and natural history of a particularly vexing health problem—heart failure with preserved ejection fraction, or HFpEF—and design and conduct clinical trials for its prevention and treatment. Lauren Balmert Bonner is another key faculty member of NUDACC leading coordinating center activities for a number of studies.



The application of quantitative methods to answer critical questions in health and medicine has created a demand for data science.



QDSC faculty and staff, 2022

QUANTITATIVE DATA SCIENCES CORE

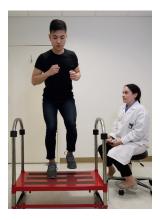
The Quantitative Data Sciences Core (QDSC) of the Robert H. Lurie Comprehensive Cancer Center is a shared resource that provides state-of-the-art biostatistics, bioinformatics, and clinical informatics support for cancer researchers. QDSC was created in 2016 when the former Biostatistics Core and Cancer Informatics Core were integrated, with the goal of providing a unified approach to experimental design, data management, analysis, and reporting. As part of this consolidation, the core has been expanded through the addition of faculty and staff effort bridging these three fields. Fred Rademaker, who led the Biostatistics Core from 1999, became the first director of QDSC, and was initially joined by associate directors for the three subcores: Denise Scholtens (Biostatistics), Matthew Schipma (Bioinformatics) and Firas Wehbe (Clinical Informatics). In 2018, Masha Kocherginsky became director of QDSC following Rademaker's retirement.

By 2022, QDSC has grown to include eight affiliated faculty and 10 affiliated staff across the three disciplines, who collaborate with cancer investigators and contribute throughout the entirety of the cancer research enterprise at the Lurie Cancer Center. Activities include design, conduct, and analysis of investigator-initiated cancer clinical trials, as well as basic science, clinical and epidemiologic studies. QDSC provides expertise in grant development, study design, statistical data analysis, implementation of standard bioinformatics pipelines and new pipeline development, and development of data capture tools and customized data management. Through close internal collaboration among QDSC members, the core is able to provide a truly integrated approach to data science that is driving novel insights into cancer therapeutics.

Phase 4

Addressing the Life Course

of Chronic Diseases and Healthy Aging



Assessing aerobic fitness among youth using a step testing protocol in the Preventive Medicine **Research** Clinic

VER THE COURSE OF THE DEPARTMENT'S 50 YEARS, THE FOCUS OF ACTIVITY HAS EVOLVED AND EXPANDED NOTABLY. Currently, the department drives innovative research focused on the origins, determinants, mechanisms, outcomes, and prevention of all of the major causes of death and disability across the entire lifespan, from preconception through gestation to birth, early childhood, adolescence and young adulthood, to middle and older ages.

Expanding the Focus to Encompass the Entire Life Course of Health and Disease

While the department was founded by Jeremiah Stamler and early activities were focused on CVD prevention, the growth of faculty expertise and methodologic approaches has led to an expansion into the study of other leading causes of death in the United States and around the world. In 2021, the top 10 leading causes of death in the U.S. were: 1) CVDs; 2) all cancers combined; 3) COVID-19; 4) accidents and injuries; 5) stroke; 6) chronic lower respiratory diseases; 7) Alzheimer's disease; 8) diabetes; 9) influenza and pneumonia; and, 10) nephritis, nephrotic syndrome and nephrosis. Through their research, investigators in the department have provided notable insights on the burden, prevention, and management of all of these and other important illnesses and conditions.

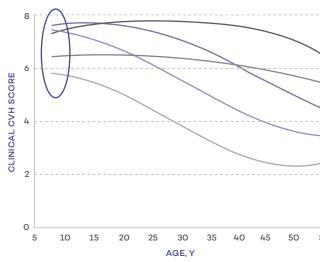
Research on CVD continues to comprise a substantial portion of the portfolio in the department, with multiple community-, clinical-, and population-based cohort studies initiated and housed in the department.

Among women, adverse pregnancy outcomes are recognized as a risk factor for future CVD events. The international Hyperglycemia and Adverse Pregnancy Outcomes (HAPO) Study's coordinating center, led by Alan Dyer and Denise Scholtens, has provided ongoing insights into peripartum risks for women based on gestational cardiometabolic health, and, through ancillary studies, the trajectories of health in their offspring into adolescence and now young adulthood, that are associated with maternal gestational health. Ancillary studies to other pregnancy cohorts, such as NuMOM2B, that measure subclinical CVD are led by investigators including Philip Greenland and Sadiya Khan. Linda Van Horn continues to lead seminal work in pregnant mothers and their offspring to address diet and weight as key drivers of pregnancy outcomes and early life health trajectories.

Faculty have expanded beyond the traditional risk factors for CVD to highlight factors that are particularly relevant to subsets of the population. Recent work, led by Donald Lloyd-Jones, Norrina Allen, and Lifang Hou, is leveraging the longstanding birth cohort of the Fragile Families Study to understand how social determinants, measured multiple times across early life, influence phenotypic and molecular aspects of cardiovascular health and subclinical disease in young adulthood. A parallel study examining gestational cardiovascular health, based on the HAPO cohort, will soon provide insights into the epigenetic and molecular bases of intergenerational transmission of cardiovascular health from gestation to offspring young adulthood. Additionally, as CVD is recognized as a process that develops across the life course, faculty including Norrina Allen, Linda Van Horn, and Amanda Perak are leading studies in newborns and children to measure behaviors that predispose to long-term CVD risk.







	cIMT (mm)
HIGH-LATE DECLINE	0.64
NTERMEDIATE-LATE DECLINE	0.67
HIGH-MODERATE DECLINE	0.67
HIGH-EARLY DECLINE	0.69
INTERMEDIATE-EARLY DECLINE	0.72

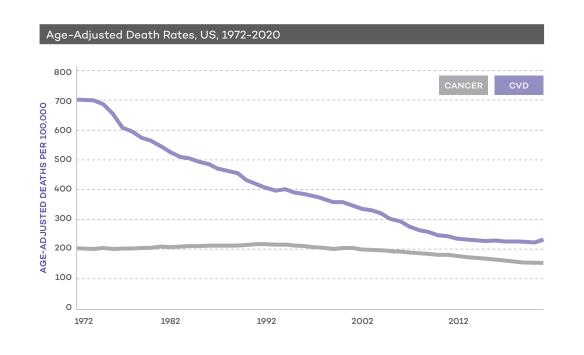
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Allen, JAMA Cardiol 2020

Above: An All of Us program staff member takes a participant's blood pressure.

Left: By pooling data from multiple longitudinal studies of youth and adults, Norrina Allen's team was able to use biostatistical tools to characterize patterns of cardiovascular health across the lifecourse and determine how those patterns relate to cardiovascular disease in middle age.

Death rates from cardiovascular disease have fallen precipitously over three decades due to earlier diagnosis and better therapies. Department investigators are actively investigating comparable strategies to change the trajectory of cancer mortality, which has been flat for decades.





Joan Chmiel, a professor of biostatistics for over 43 years, played an integral role in large HIV cohort studies.

Addressing cancer from multiple perspectives—including prevention, treatment, and survivorship has led to multiple lines of research. The contribution of the environment to individual biology, down to the molecular level, is a focus of the work of Lifang Hou, Wei Zhang, William Funk, Yinan Zheng, Brian Joyce, and their research teams. Strategies to prevent and treat cancer using interventions that target multiple behavior changes independently and in combination are a significant focus of activity in the Division of Behavioral Medicine. With greater detection and diagnosis of cancer, faculty aim to optimize life after cancer by identifying the behaviors, biological factors, and social determinants associated with cancer recurrence and the development of other chronic diseases.

The epidemic of human immunodeficiency virus (HIV) and acquired immune deficiency syndrome (AIDS) in the 1980s marked one of our department's first entrees into infectious disease research. With effective treatments now available for decades. HIV infection has become a chronic disease. and people with HIV are far more likely to be afflicted with chronic diseases of aging, including certain cancers and all forms of CVD. Joan Chmiel played an integral role in large HIV cohort studies, and more recent faculty members like Matthew Feinstein have generated novel insights into the pathogenesis of CVD in persons living with HIV, showing that risks are enhanced by the pathophysiology of HIV infection, associated chronic inflammation, and, in some cases, long-term adverse physiological side effects of some antiviral medications. The current urgency of infectious diseases, including the SARS-CoV-2 that propelled COVID-19 infection to the third leading cause of death in 2020 and 2021, has prompted engagement by Charlesnika Evans, John Wilkins, and Mercedes Carnethon on the side of scientific discovery, the impact of COVID-19 on healthcare workers, and through contributions to the public discourse on disease mitigation strategies.



Many of the leading causes of death share a "common soil"-a common set of underlying causal risk factors, including adverse health behaviors (e.g., poor diet, sleep disturbances, physical inactivity), psychological distress, and indicators of poor health such as obesity and diabetes. Our study of those factors has led to an expansion into other leading disease outcomes. For example, the substantial infusion of money by the NIH to study Alzheimer's disease and related dementias has catalyzed the department's portfolio in that space. Norrina Allen leads a large NIAfunded international consortium harmonizing data from numerous population-based cohorts to understand risk factors and mitigating factors in development of dementia across the life course. Department research teams are investigating how behaviors including sleep and psychological distress contribute to Alzheimer's and dementia and how these factors may contribute to racial and ethnic disparities in these outcomes. Beyond physiological risk factors, numerous faculty members, notably Kiarri Kershaw, have made key insights into effects on health of structural racism and segregation, neighborhood food availability, psychosocial factors, and other social determinants of health across the life course.

Other chronic diseases of aging have also merged as key targets of study for department faculty. The role of physical inactivity and obesity on osteoarthritis, a leading cause of disability and loss of independence for older adults, is the focus of collaborative research between department faculty, including Rowland "Bing" Chang, Julia Lee, Lutfiyya Muahammad, and others with investigators in the Division of Rheumatology, spanning investigations from basic discovery science to interventions designed to improve outcomes. Other collaborations with the Division of Pulmonology have also been fruitful, leading to the establishment of the first ever cohort study focused on capturing the trajectory of ideal lung health across the life course. This large national inception cohort, jointly funded by the American Lung Association and NHLBI, will focus on identifying a common set of risk factors that trigger the loss of optimal lung function with aging.

Psychological health, well-being, and mental health issues underlie and enhance (positively or negatively) one's risks for each of the leading causes of death. Novel research by multidisciplinary teams composed of behavioral scientists and engineers in our Center for Behavioral Intervention Technology is exploring strategies to deliver mental health interventions via mobile technologies to make them broadly accessible to populations at risk. Overall, department faculty continue to be responsive to the leading threats to health in the U.S. and around the world.

Donald Lloyd-Jones mentors a junior colleague.

Psychological health, well-being, and mental health issues underlie and enhance one's risks for each of the leading causes of death.



Study participant undergoing a blood draw.

Our understanding of disease processes in humans would not be possible without the generous contributions of adults and children who join our research studies.

Faculty and trainees in the department disseminate their findings in the leading journals in public health, medicine, education and biostatistics.

Cardiovascular Health Across the Life Course

The work of Jeremiah Stamler, Kiang Liu, Martha Daviglus, and others in the department on the concept of the low-risk phenotype inspired much of the bold new concept enshrined in a formal definition of cardiovascular health (CVH) by the AHA in 2010. Based on decades of research, CVH combined information on seven health behaviors and health factors (Life's Simple 7TM), including diet, physical activity, smoking, body mass index, blood cholesterol, blood glucose, and blood pressure. Each metric was categorized as ideal, intermediate, or poor, based on clinical thresholds; overall ideal CVH was defined by the presence of all seven metrics at ideal levels, but it was rare (<1% of Americans at all ages, driven by poor diet scores).

Since 2010, the scientific community has engaged with the concept of CVH in depth in order to understand its determinants, mechanisms, and outcomes across the life course. By 2022, there were more than 2,500 publications about CVH, many led by department investigators and trainees. Results have shown that CVH may be a particularly powerful way to measure health and understand trajectories and future risk in children and young adults, when clinically elevated risk factors are rare. At every stage of life, high CVH is associated with greater lifespan, healthspan, and compression of morbidity, lower incidence and progression of subclinical disease, and more favorable health outcomes related to cancer, dementia, and all other major chronic diseases of aging. At the same time, whereas people with high CVH live longer, they require less healthcare and incur lower healthcare costs over their Medicare lifespan. Early life CVH is associated with midlife

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epigenetic changes that in turn appear to mediate the burden of midlife subclinical CVD. These, and other exciting insights about CVH, based in existing cohorts and trial datasets from the Lifetime Risk Pooling Project to CARDIA, MESA, and beyond, have provided novel insights into the life course, determinants, molecular mechanisms, and outcomes associated with better CVH at every stage of life. As predicted by Jeremiah Stamler, the effect of having the package of optimal risk factors (and lifestyles) incorporated in CVH appears to be greater than the sum of the component parts. As a result of this extensive body of research, AHA updated the concept of CVH in 2022, adding sleep as an eighth metric (Life's Essential 8TM) and enhanced the scoring algorithms for the other metrics and overall CVH to allow for better discrimination of inter-individual differences in CVH

and intra-individual changes in CVH over time. This new approach to quantifying CVH will keep department investigators busy for years to come, particularly since its genesis stems from some of the earliest and most profound insights made by department faculty decades ago.

Summary

Across all of these areas of study, and many others, the department is leading and driving critical insights that will provide opportunities to leverage policy, clinical, community, pharmacologic, and behavioral interventions that promote health and prevent disease far into the future. Building from our solid foundation of methodological tools to design efficient research studies, to our experience successfully recruiting and enrolling study participants, research from department investigators will continue to lead the field of prevention and to advance human health. These same research programs and projects will serve as the platforms for the education, training, and launching of countless junior investigators for decades to come.

RESPONDING TO COVID-19

In the early months of the COVID-19 pandemic in Chicago, the department and allied faculty established the Northwestern Medicine Healthcare Worker SARS-CoV-2 Serology Study to quantify the prevalence of anti-SARS-CoV-2 IgG antibody positivity across different types of Northwestern healthcare workers, to quantify the incidence of serologic conversion, and to explore the risks for incident COVID-19 associated with serologic status.

In May and June 2020, the team, led by John Wilkins and Charlesnika Evans, and catalyzed by funding from the NUCATS Institute and critical assistance from Northwestern Memorial HealthCare, enrolled 6.510 Northwestern Medicine healthcare workers from across the health system. At baseline (June 2020), they obtained detailed information on demographics, occupational exposures, and personal history of COVID-19 symptoms, testing, and diagnoses using electronic surveys. They used the Abbott Architect Nucleocapsid IgG assay to determine participant serologic status and banked serum from approximately 5,000 cohort participants for suture studies. Using monthly electronic surveys and linkage to participants' electronic medical records, the team followed this cohort of healthcare workers for over two years (to date) to assess the risks for developing incident COVID-19, post-recovery sequelae, psychological well-being, job-related burnout, and other outcomes related to COVID-19.



To date, the cohort has published three manuscripts, and the team has received external funding from the Peterson Foundation to continue its work understanding healthcare worker burnout during the COVID-19 pandemic. The rapid and nimble generation of this collaboration across disciplines stands as a remarkable testament to the multi-disciplinary skills, innovative thinking, and resolution of department faculty and partners to improving human health, even in the face of rapidly evolving public health emergencies.

In another project, department faculty, led by Jaline Gerardin's Malaria Modeling Team, re-applied their extensive experience using analytics to support public health decision-making toward Illinois's COVID-19 response. The team built a simulation model to supply weekly forecasts of epidemic trends at the sub-state level, including predicting upcoming hospital and ICU needs and identifying what appropriate thresholds for action could be. State public health and safety officials included these predictions as part of their regional assessments to relax or tighten mitigations. Gerardin and her team also quantified racial and ethnic disparities in test access, case burden, hospitalizations, and deaths across the state and found that differences in exposure risk drove disparities in COVID-19 burden. They identified under-tested populations to inform mobile test site placement in Chicago and worked with state and city public health departments to set up and evaluate sentinel surveillance programs to provide early warning on changes in transmission. The team also collaborated with a team at Stanford University to use mobile phone data to assess the impact of mobility in the early phase of the pandemic and identify high-risk establishments. The net result of the rapid pivot to COVID-19 analytics were instrumental in guiding state and city officials to prepare, respond, and manage the rapidly shifting demands of the health care and public health systems during this once-in-a-century public health catastrophe.

Health and Preventing Disease

The Department of Preventive Medicine at 50

Focusing on the Future of Improving

STAFF REFLECTIONS



"I had the pleasure of working in the department under the leadership of Dr. Donald Lloyd-Jones and Andrea Minogue who will forever be my most important mentors. In my time at DPM, I witnessed our exponential growth, making us the most funded public health department in the nation. I am not surprised that the 'good work' in the last 50 years has resulted in the department's well-deserved success."

TASNEEM UTING. FORMER ASSOCIATE DIRECTOR FOR RESEARCH ADMINISTRATION

Departmental Scope, Mission, and Vision

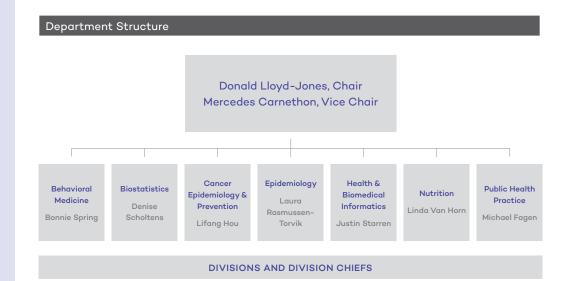
In 2016, in preparation for the decennial departmental review by the university, Donald Lloyd-Jones and Mercedes Carnethon led the entire faculty in a visioning exercise to redefine its mission and vision. Through multiple rounds of discussion and refinement, rather than produce traditional mission and vision statements, the faculty chose to answer four key questions about the department. The results of that process, relevant to the present and future of the department, are shown below.

WHO WE ARE: We are multidisciplinary health scientists who focus on improving health and preventing disease across the life course in individuals and diverse populations.

WHAT WE DO: We conduct innovative, collaborative research to understand the etiology and mechanisms of health, well-being, and disease, and to test and disseminate strategies for health promotion and disease prevention. We also train and empower the next generation of health scientists to address our foremost public health challenges.

HOW WE DO IT: We develop, apply, and teach cutting-edge research methods, informatics, data analytics, and technologies to understand and enhance health from molecular, individual, community, and global perspectives.

WHY WE DO IT: We aim to advance the science of health promotion and disease prevention to create measurable and meaningful improvement in human health.



As the department has grown from a handful of members to over 100, the leadership structure has expanded to include divisions that are led by a diverse team of division chiefs.

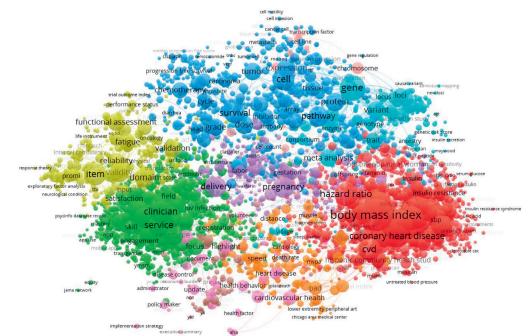
Impact of Departmental Science Over Time

Using state-of-the-art analytic tools, the team at Feinberg's Galter Health Sciences Library, directed by faculty member Kristi Holmes, have refined our ability to understand the scientific impact of the department's work over the last 50 years. It has been nothing short of remarkable.

From 1972 through the end of 2021, department faculty published a total of 15,237 scientific publications, including original science journal articles, book chapters, scientific statements, clinical practice and public health guidelines, and more, for an average of 311 publications per year. The number of annual publications increased from 8 in 1972 to 1,223 in 2021, a 150-fold increase. Among these publications, department investigators have collaborated with co-authors from 157 other countries on six continents. In total, these documents have been cited 883,000 times in other manuscripts by authors from 196 countries around the globe, or more than 18,000 times per year on average. The mean number of citations per publication is extraordinarily high, at 58.

The topics of these publications fall into clusters, as shown in the figure below. Broadly, these clusters represent domains of cancer, genomics, cardiometabolic conditions, general epidemiology, health behaviors, policy and guidelines, aging, and gestational health.







"I have been with the Department of Preventive Medicine for more than half the time the department has been in existence! My personal passion has always been prevention and I always like to know the "why" of things. Thus, when I came to Preventive Medicine twenty-seven years ago, it fulfilled both my professional and personal passions. I've had the true honor to work under amazing department leadership throughout the years, with special thanks to Dr. Philip Greenland and Dr. Donald Lloyd-Jones, who have been wonderful mentors and supervisors."

SUE GIOVANAZZI, RESEARCH CLINIC DIRECTOR



"I applied to my position based on the exceptional reputation of the chair, Donald Lloyd-Jones, and to work with public health faculty again. This department is so special—we have some of the hardest working faculty and staff who go above and beyond to support our mission and genuinely care about others.'

ELIZABETH BUDZIK, DEPARTMENT ADMINISTRATOR



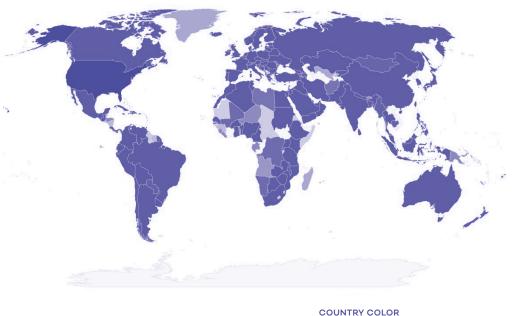
"I started working for CARDIA in 1985 as the receptionist. Each morning a worker from NORC would call in with the day's appointments. No fax machines, e-mail. or internal database then! As retention coordinator, I reach out to participants to stay connected with them. I am very grateful for the opportunity to work with such wonderful leadership, staff, and dedicated participants."

SHIRLEE MOHIUDDIN, RESEARCH STUDY COORDINATOR SR.

Departmental manuscripts have appeared in scientific journals with the highest impact factors, including Cancer, The New England Journal of Medicine, Lancet, JAMA, Nature, and all of the major epidemiology, general medicine, cardiovascular, and behavioral medicine and lifestyleoriented journals.

Tracking the country affiliations of citing authors provides tangible information on how research has disseminated in the scholarly community. The citing authors represented 196 countries including the United States. The figure represents the global dissemination of the faculty's publications, and their influence on an international audience.

Global Citing Author Affiliations

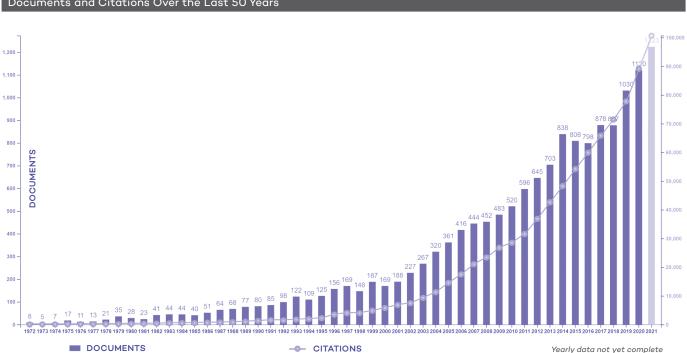


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The 15,237 documents by the faculty of Department of Preventive Medicine from 1972-2021 were cited 882,959 times in the same time period. Each country is color-coded in proportion to the number of author affiliations of citing works from that country.

The growth of the department from a small team focused on a single disease area-cardiovascular disease-to over 100 faculty, staff and trainees investigating leading causes of morbidity and mortality around the world has resulted in a proportional growth in research activity. Year over year increases in the number of research articles published in science and medicine journals are followed by subsequent citations of that work by investigators around the world. Within 50 years, the over 100,000 cumulative citations of the research generated by department members has been used to promote disease prevention and the preservation of health across the lifecourse.

Documents and Citations Over the Last 50 Years





"When I think about what is next for the Department of Preventive Medicine, I see limitless possibilities. For us to have gone from a department comprised of 10 people working on a single disease area in 1972 to the breadth of diseases and health behaviors we study in 2022, is a reflection of what happens when passionate, committed and collegial people come together with a singular focus on prevention. The multitude of studies, training opportunities and intellectual capacity we hold as a group will allow us to continue to innovate to meet any of challenges that public health and medicine present."

MERCEDES CARNETHON, PHD VICE CHAIR, DEPARTMENT OF PREVENTIVE MEDICINE





Darwin Labarthe hosted the first international seminar in the United States in 2020-2021.

Training Generations of Scientists

INTERNATIONAL AND U.S. TEN-DAY TEACHING SEMINARS ON CARDIOVASCULAR EPIDEMIOLOGY AND PREVENTION

The International Ten-Day Seminar on Epidemiology and Prevention of Cardiovascular Disease was born in the department's pre-conception phase, in 1966, immediately following that year's World Congress of Cardiology in Delhi. Jeremiah Stamler and Ancel Keys had just been designated to lead the newly established Council on Epidemiology and Prevention of the International Society of Cardiology.

Keys and Stamler sought immediately to fulfill a vision of a worldwide cadre of workers, "a mobilized global research community committed to putting CVD prevention on the world agenda." This would require a dedicated international faculty of leading investigators in the field, attraction of promising early-career fellows throughout the world, an annual succession of hosts in many countries, and an institutional base, all to be sustained for the foreseeable future. This unique 10-day residential program, with its close academic and social interactions between fellows and faculty, was launched in 1968.

For many years from 1972 onward, the department was that institutional base, with Jeremiah Stamler as a long-term member of the faculty and later seminar director, and Rose Stamler as devoted seminar coordinator and member of the faculty. The 51st International Seminar was hosted for the first time in the U.S. by this department in 2020-2021. In the decades since its establishment, hundreds of fellow attendees have gone on to become leading researchers, clinicians, and public health advocates in more than 50 countries.

The highly impactful model of the International Seminar was faithfully replicated in the U.S. by Darwin Labarthe, beginning in 1975. Jeremiah Stamler was a prime mover behind establishing the U.S. Ten Day Seminar and a founding member of that faculty. The department has been strongly represented throughout the seminar among both faculty members, including Philip Greenland, Mercedes Carnethon, Donald Lloyd-Jones, Darwin Labarthe, and numerous fellows.

Over the past half-century, the department has contributed continually and substantially to both of these unique, immersive training programs, and their faculty and annual cadre of fellows, with more than 2,800 trainees to date.

Inaugural seminar faculty members, Makarska, Yugoslavia, 1968





THE PROGRAM IN PUBLIC HEALTH

In the 1970s and 1980s, there was an unaccredited Master of Public Health (MPH) degree program established in the department, which offered the MPH degree to medical students and others under the sponsorship of the Northwestern University Medical School. A departmental review committee examined the course offerings and graduation rates and recommended that the program be discontinued, which it was in approximately 1990. Soon after the program's demise, the new chair, Philip Greenland, assembled a committee to study the feasibility of sponsoring an MPH degree program accredited by the Council on Education in Public Health (CEPH).

After a year of planning using the CEPH accreditation requirements as a blueprint, the MPH degree program received institutional approval and was re-established in 1996 as part of The Graduate School. The first group of MD/MPH students began their studies in September 1996 and a small cohort of MPH students matriculated in winter 1997. Rowland "Bing" Chang was the inaugural director of the program. The program held its first graduation and gained provisional accreditation in 2000 with an inaugural graduating class of six students, all of whom completed the degree program as part-time, evening students.

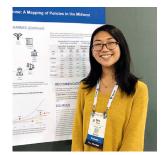
Doctoral students interested in public health made a case for combining their doctoral work in the life sciences with evening classes in public health, and the first graduate of the MPH/PhD program graduated in 2003 followed by one or two or more per year. Doctoral students in anthropology followed and the program graduated the first MPH/PhD in anthropology in 2008. Some "one-off" PhD/MPH students have graduated with doctoral degrees in industrial engineering, audiology, and neuroscience. Other students completed JD and MBA degrees while concurrently enrolled in the MPH program but not in formal combined degree programs. In 2021, the first cohort of two Doctor of Physical Therapy/MPH students completed the combined degree program with degrees in public health and physical therapy.

In 2009, Rebecca Wurtz became the MPH program director and Michael Fagen followed in fall 2014. Leah Neubauer joined as PPH's associate director in 2021. The MPH program gained a sibling in 2007 with the establishment of the MS in Epidemiology and Biostatistics (MSEB) under the direction of Mercedes Carnethon. Mary Kwasny became the second MSEB director, and by 2017 the program was renamed the MS in Biostatistics under the leadership of Denise Scholtens. In 2019, Jody Ciolino took the reins as director of the MS in Biostatistics. The program was established as a full-time daytime program that started as a five-quarter program of study and was collapsed in 2010 into a four-quarter sequence that could be completed in one year, which greatly increased its popularity. Rowland "Bing" Chang teaches a course in the Public Health program.

The first graduate of the MPH/PhD program graduated in 2003. American Public Health Association Expo in 2014. First year Michael Fagen was with the Public Health Program.



Offering daytime classes in epidemiology and biostatistics opened the door to a full-time MPH degree program that could be completed in four quarters from mid-June through mid-June of the following year. The first of these students graduated in 2017. The one-year program made possible the development of a 4+1 degree program for Northwestern undergraduates that in August 2016 was named the Accelerated Public Health Program (APHP), which admitted students in the spring of their junior year to begin their MPH degree just days after college graduation with MPH graduation a year later. The first APHP cohort graduated in 2019.



MPH student presenting at the American Public Health Association annual meeting in 2019.

The MPH and MS programs currently reside within the Institute for Public Health and Medicine (IPHAM) and they remain under the direction of department faculty, who also comprise the vast majority of teaching faculty. The unequivocal success of these programs and the need for expanded expertise in epidemiology and public health is leading to the launch of a separate degree program (MS in Epidemiology) in fall 2022. Since 1999, the MPH and MS in Biostatistics programs have graduated 582 students. Both programs have robust current enrollment, including 18 MS in Biostatistics and 118 MPH enrollees as of June 2022, ensuring their contributions to training generations of experts will continue for many years to come.

T32 TRAINING PROGRAMS

Postdoctoral training that provides investigators and clinicians with the skills needed to pursue research-intensive careers is a high priority for the department. Since the department's first National Institutes of Health (NIH)-sponsored T32 postdoctoral training program started in 1975, the department has trained scores of investigators who have pursued successful careers in academics, government, and industry. The department's ability to provide high-quality training across an expanded range of research areas stems from the shared commitment of our faculty to education and the extensive research expertise and data resources we have available in our scientific environment.

The department is currently home to three T32-funded postdoctoral training programs: 1) Cardiovascular Disease Epidemiology and Prevention; 2) Behavioral and Psychosocial Research Training in Cancer Prevention and Control; and 3) Multidisciplinary Training in Digital Mental Health. Each of these training programs supports up to four postdoctoral trainees in any given year, who are mentored by faculty across the department and school. Fellows who are supported by T32 programs are joined by trainees supported through other funding mechanisms from individual grants (e.g., F31 and F32 awards) and contracts (e.g., diversity supplement awards from NIH) or other professional societies (e.g., the American Heart Association Strategically-Focused Research Networks). Notably, these training grant programs support one another by offering shared professional development training, opportunities for research collaboration, and faculty mentors.

At many institutions, completing a postdoctoral training program is a pathway toward a faculty position at that same institution. By contrast, we have enriched our professional field by facilitating even more placements outside of our institution than within. In doing so, faculty maintain a broad network of collaborators and continued collaborative work long after the postdoctoral training period is over. Future directions in training will ideally include expansion into predoctoral training with the growth of doctoral programs, including the new PhD track in Biostatistics, and concentration areas within the Health Sciences Integrated Program for doctoral training on topics relevant to disease prevention.

PHDS IN INFORMATICS AND BIOSTATISTICS

The rising international impact and innovative data types involved in clinical and public health studies, coupled with the general explosion of data science worldwide, demand methodologic innovation and provides unmatched opportunities for student training. To meet these needs, department faculty partner with the Health Sciences Integrated Program at Feinberg to provide doctoral level training in quantitative sciences.

Doctoral training in Health & Biomedical Informatics (HBMI) was founded by Justin Starren in 2012 as a track in the Driskill Graduate Program. An HBMI track was also part of the founding of the Health Sciences Integrated Program (HSIP) in 2013. In 2020, both tracks were consolidated under the HSIP Program. The first student earned their PhD in 2017, and the program has since graduated 14 doctorates, with 24 students currently enrolled. Research areas cover the range of informatics from epigenomics to precision medicine to social determinants of health. Northwestern HBMI PhD students have gone on to accept postdoctoral positions at leading institutions such as Harvard, Columbia, and University of Chicago. Others have become data scientists at leading corporations such as Regeneron. Notable achievements of students include being selected as a Northwestern University Presidential Fellow and winning the INVOForward Shark Tank Competition at the university.

Reflecting exciting new growth of doctoral training initiatives, the first three students of the HSIP Biostatistics PhD track of the HSIP program will matriculate starting fall 2022. After years of careful planning by a Division of Biostatistics PhD Program Working Group led by Lihui Zhao, and building on the outstanding success of the MS in Biostatistics program, students in this new PhD program will enjoy a curriculum that is closely integrated with the Department of Statistics on the Evanston campus and incorporates specific statistical challenges that arise in health research. Biostatistics doctoral research projects will emphasize both methodologic development and innovative collaborative applications. The opportunity for faculty to work with biostatistics doctoral graduate students promises a whole new level of potential impact in biostatistics science and practice.



Nicholas Soulakis teaches an informatics course.

Emerging Research Leaders in Preventive Medicine

The department has always been fueled by the innovative ideas of its junior faculty. Below we highlight some of the emerging leaders in the department.



NABIL ALSHURAFA, PHD

Nabil Alshurafa is an associate professor of Preventive Medicine and of Computer Science and Electrical and Computer Engineering. He received his PhD in computer science at the University of California Los Angeles. He currently directs the NIH- and NSF-funded HABits Lab, which aims to bridge computer science and behavioral science research. His current research seeks to enable passive assessment of eating with the goal of designing technology-supported lifestyle treatments for obesity. His long-term goal is to design mobile health systems that combine machine learning and wearable sensors to understand human behaviors in their natural setting, as well as psychological state and environmental context, with the ultimate goal of designing interventions that help manage symptoms, prevent illness, and improve health and well-being.



AMANDA MARMA PERAK, MD, MS, FACC, FAHA

Amanda Perak earned her BA from the University of Chicago in 2004, her MD from Northwestern University Feinberg School of Medicine in 2009, and an MS in Clinical Investigation from Northwestern University in 2018. She completed her pediatrics residency and pediatric cardiology fellowship at Boston Children's Hospital of Harvard University. In 2015, she returned to Northwestern for advanced cardiac imaging training and a T32 fellowship in preventive medicine, and then became an assistant professor of Pediatrics and Preventive Medicine at Northwestern in 2018. She currently practices clinical pediatric preventive cardiology at Northwestern's pediatric affiliate, Lurie Children's Hospital. Current research studies include examining the effects of dietary interventions on the microbiome in children and the influence of social determinants of health on cardiovascular health across childhood and adolescence. The long-term goal of her research program is to develop early-life interventions and strategies to promote optimal cardiovascular health in youth and their families to promote lifelong cardiovascular health.



LAUREN BALMERT BONNER, PHD

Lauren Bonner is an assistant professor in the Department of Preventive Medicine, Division of Biostatistics. Her research interests lie in clinical trial design and analysis, connecting methodological developments with clinical applications. As a member of the Biostatistics Collaboration Center and Northwestern University Data Analysis and Coordinating Center, she facilitates and promotes scientific research as a collaborative biostatistician across a range of clinical fields, including HIV maternal/child health, gastroenterology, and pediatric medicine. She currently serves as the lead biostatistician for several studies: a cluster randomized trial assessing the effectiveness of a walking intervention on reducing frailty; a phase II pharmacodynamic study in patients with critical COVID-19 pneumonia; and two concurrent trials comparing interventions for pediatric arm fractures. Her statistical leadership has promoted rigorous study design, planning, and execution. She is committed to supporting high-impact clinical studies, efficiently addressing scientific questions, and advancing research through statistical innovation.



YINAN ZHENG, PHD

Yinan Zheng joined the department as a doctoral student and is currently an assistant professor. His research focuses on studying multi-omic biomarkers that predict the risk and progression of aging-related diseases, including CVDs and cancer. He develops novel data science tools to integrate and analyze multi-omic data generated in large population-based and clinical studies. His conviction is that robust and efficient analytical methods for multi-omics data will continue to be the driving force in the next decades to bring breakthroughs in human aging research, and his cutting-edge research and methods development work to advance those goals. His personal goal is to become an independent researcher and identify new molecular biomarkers for aging-related disease screening and precision medicine-based intervention strategies.

DIANA CHIRINOS, PHD

Diana Chirinos is an assistant professor in the department. She is a licensed clinical psychologist with training in public health and behavioral medicine. Her work focuses on understanding the role of demographic and psychosocial factors as determinants of cardiovascular health. Specifically, she is interested in: 1) characterizing the cardiovascular risk profile of vulnerable populations, such as ethnic minorities or bereaved individuals; and 2) elucidating the biobehavioral pathways underlying the relationship between chronic stressors, such as depression or sleep disturbances, and CVD outcomes. Her long-term goal is to design well-informed targeted interventions to reduce the burden of chronic stress and CVD among vulnerable populations.



Sadiya S. Khan is an assistant professor of Medicine and Preventive Medicine at Northwestern University Feinberg School of Medicine. Her clinical expertise and research focus is on the epidemiology, prevention, and genetics of heart failure with an emphasis on sex-specific risk factors such as adverse pregnancy outcomes. Her research spans the spectrum from preclinical basic research, population-based studies, and clinical trials. She is committed to improving cardiovascular health across the life course, beginning in utero, and across generations. Her research efforts are supported by grants from the National Institutes of Health and the American Heart Association. She has published >190 peer-reviewed scientific research publications in leading medical journals and her work has been cited over 9,700 times (Scopus, May 2022). She is an associate editor at JAMA Cardiology and serves as the vice chair of the American Heart Association Epidemiology Publications Committee.

In Memoriam

REMEMBRANCE OF JEREMIAH STAMLER. MD BY PHILIP GREENLAND, MD

was fortunate to follow Jeremiah (Jerry) Stamler as the department's second permanent chair. Jerry was the founding chair and served in that role from 1972-1986, when he became emeritus professor, a position he held as an active researcher, mentor, and teacher till his death in 2022, at the remarkable age of 102.



Jerry was well known for his "Lectures in Preventive Cardiology," which were the basis for his teaching both at Northwestern and around the world. Many considered him the "father of preventive cardiology," and his leadership contributed to many organizations and projects, including the American Heart Association,

the National Institutes of Health, several medical journals, the International Seminars in Cardiovascular Epidemiology (which he founded), and large multi-center prevention trials and observational studies. He was generous with his knowledge and his time, and he had a large and devoted following who were eager to join him in his efforts to stamp out the epidemic of heart and vascular disease. Through him, I was introduced to colleagues in Britain, Italy, Belgium, Japan, China, and the United States, and I saw first-hand the way he was able to recruit others to join his research campaigns.

On a personal level, I was initially intimidated by the idea of following in the footsteps of a legend more than 30 years my senior. Despite his vast reputation and experience, he was always generous to me and treated me as an equal, which I appreciated immensely. He promised even before I began as chair to "never get in my way or interfere," and he kept his word. I was impressed not only by his sensitivity, his brilliance, and his humanity, but also by his ability to persevere through

many challenges. The biggest challenge I saw him conquer was the tremendous loss of his first wife, Rose. He was clearly diminished by the loss and his productivity dipped for about a year after Rose died, but then he overcame the grief and resumed his work full force. His eventual marriage to Gloria Beckerman, a childhood sweetheart, was rejuvenating to him and was inspiring to many of us who admired the two of them as a couple. I was able to visit their home in Pioppi, Italy along with my wife shortly after the two of them were married, and it was a joy to see them together there, as it was in Chicago and elsewhere around the world.

Jerry overcame many challenges, including physical limitations due to orthopedic problems dating back to his childhood. He also overcame tremendous societal challenges. His battle with the House Un-American Activities Committee (HUAC) is legendary, and it stamped him as a champion of civil liberties as well as a world leader in CVD prevention.

Many of us in the department benefitted from Jerry's mentorship and friendship, and several faculty members devoted many hours of their personal time to help Jerry manage his affairs in his later years, especially after Gloria's death a little more than one year before his own. I think everyone who knew him regarded him as an intellectual giant, an honest and honorable individual, an outstanding researcher, and a humanist. Northwestern University and the Department of Preventive Medicine benefitted greatly from his role as founding chair and in his long-term role as an "emeritus" faculty member from 1987-2022.



BETTY HAHNEMAN

Betty Hahneman joined the Department of Preventive Medicine as an adjunct associate professor in 1997.

She had earned a Master of Public Health degree from the University of South Carolina after retiring from a career in internal medicine and hematology on Chicago's West Side and returned to Chicago wanting to serve as a volunteer in a way that used her experience in medicine and public health. The alumni office directed her to the department's Program in Public Health, where she became the director of special projects, which included the program's efforts toward provisional accreditation by the Council on Education in Public Health (CEPH) in 2000, and CEPH site visits in 2002 and 2010. She assured that the learning objectives in the syllabi were "observable and measurable" and served as a liaison to the medical school's alumni office. She was honored in 2003 with a Northwestern Alumni Association service award. She was the first president of Northwestern's Beta Eta Chapter of Delta Omega Honorary Society in Public Health established in 2006. Even after her "retirement" in 2010, she was frequently in attendance at student presentations and graduation celebrations. She passed away in July 2019 at the age of 91, having left an indelible mark through her gentle and inspiring leadership on generations of MPH students and the department as a whole.



VIRGINIA "GINI" BISHOP

Virginia Bishop, MD, MPH, was an assistant professor in the Division of Public Health Practice and assistant director of diversity and inclusion for the Feinberg School of Medicine.

She joined the Program in Public Health (PPH) and the faculty of the department in 1999 while also working as a private practice pediatrician in the East Ukrainian Village neighborhood. Her responsibilities included the placement of students in field experiences (now called Applied Practice Experiences), serving as co-chair of the Community Engagement Committee, service on numerous PPH committees, and as course director of "The Role of Community in Public Health." She died in February 2020 at the age of 60. She is remembered as a passionate advocate for public health in medicine and was a great friend and advisor to many faculty and students for more than two decades.

