National Institutes of Health
Office of Science Policy

THE FRAMINGHAM HEART STUDY:
LAYING THE FOUNDATION FOR PREVENTIVE HEALTH CARE

By the early 1920s, diseases of the heart consistently ranked as the #1 cause of death in the United States.[1] Even the President was not immune to this emerging health concern: Franklin Delano Roosevelt died of hemorrhagic stroke in 1945 due to uncontrolled hypertension, raising awareness about the rising toll of cardiovascular disease. Driven by the need to understand this growing threat, the Framingham Heart Study ("Framingham") was started in 1948 by the U.S. Public Health Service and transferred shortly thereafter to the newly established National Heart Institute (now the National Heart, Lung and Blood Institute [NHLBI]) of the National Institutes of Health [NIH]). One of the first long-term cohort studies of its kind,[2] Framingham would become known as the crown jewel of epidemiology.

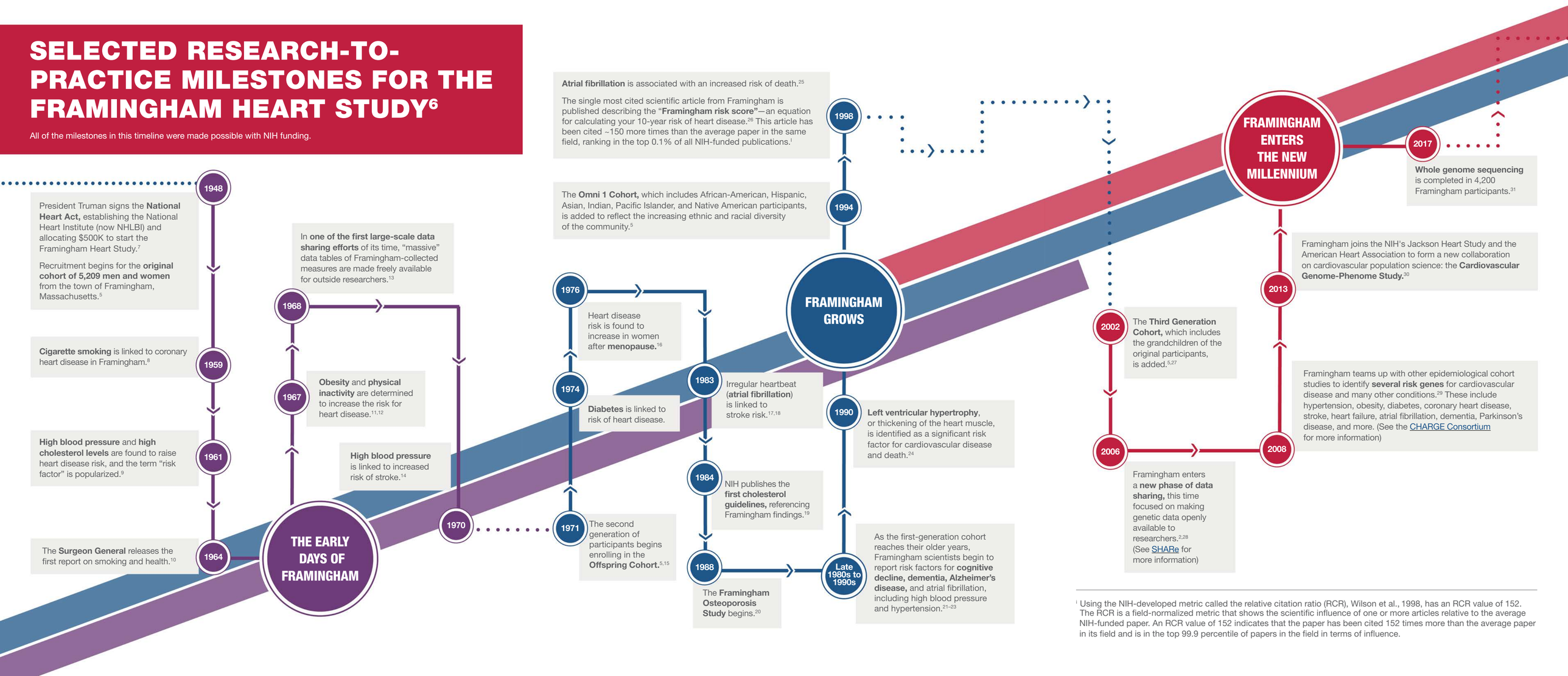
The study has not only contributed enormously to our understanding of the natural history of cardiovascular disease and stroke, it also enabled us to identify their major causal risk factors. Framingham changed the way we study and approach chronic diseases in the medical and public health spheres. Thanks in large part to Framingham, we now go beyond treating disease once it occurs by emphasizing disease prevention and addressing modifiable risk factors. Framingham was an early pioneer in the use of epidemiology to study non-infectious diseases and gave rise to innovative methods that are being put to use in countless studies across the world. The overall impact of the Framingham Heart Study is vast, and the study continues to unveil new insights into human health to this day.

WHAT IS THE FRAMINGHAM HEART STUDY?[3]

The study, which aimed to unravel the underlying causes of heart disease, started in 1948 with 5,209 participants in the town of Framingham, Massachusetts. Framingham is a longitudinal cohort study, a type of epidemiological study that follows a group of individuals over time to determine the natural history of certain diseases, explore the behavior of those diseases, and identify the factors that might explain their development. Part of the reason Framingham, Massachusetts was picked as the study site was because it was just big enough to provide a sufficient number of individuals for the study, while also small enough to be suited to the community approach of recruiting and effectively following participants over time.[4,5] Participants underwent physical examinations, gave blood samples for laboratory tests, and provided lifestyle and medical history information at regular intervals. Now a joint project of the NHLBI and Boston University, Framingham has expanded over the years, both in geographical and population scope. Today it includes many grandchildren and spouses in three generations of participants, as well as two cohorts of minority participants (the Framingham Omni Cohorts).

SELECTED RESEARCH-TO-PRACTICE MILESTONES FOR THE FRAMINGHAM HEART STUDY[6]

All of the milestones in this timeline were made possible with NIH funding.



[i] Using the NIH-developed metric called the relative citation ratio (RCR), Wilson et al., 1998, has an RCR value of 152. The RCR is a field-normalized metric that shows the scientific influence of one or more articles relative to the average NIH-funded paper. An RCR value of 152 indicates that the paper has been cited 152 times more than the average paper in its field and is in the top 99.9 percentile of papers in the field in terms of influence.

IMPACTS

BEFORE AND AFTER THE FRAMINGHAM HEART STUDY

THEN

In 1968, death rates from heart disease hit their peak, accounting for nearly 750,000 American deaths.[1]

- Heart disease was usually treated only after it affected health, such as after a heart attack.
- Heart disease became the leading cause of death by the early 1900s.[1, 34]
- The effects of smoking, cholesterol, and obesity on heart disease and stroke were not known.[2]
- High blood pressure was seen as an inevitable consequence of aging, and all but the most severe cases were untreated.[36]
- The term "longitudinal cohort study" did not exist in the 1940s, and epidemiological studies were conducted primarily on infectious diseases.[32]

NOW

From 1969 to 2013, U.S. deaths from heart disease fell 67.5% and deaths from stroke fell 77%.[33]

- The concept of risk factors has paved the way for preventive approaches to disease. People can take control of their personal health risks through lifestyle modifications and medical treatments.
- Hypertension treatment, cholesterol reduction, and smoking cessation have contributed to a 50-year decline in cardiovascular deaths.
- Framingham identified that the lifetime risk of hypertension was 90%. Blood pressure and cholesterol issues are among the top 10 reasons people visit their doctor.[35]
- Inspired by Framingham and other early studies, there are now hundreds of longitudinal cohort studies conducted worldwide, and epidemiologic tools are now commonly used to understand chronic conditions.[37]

HEALTH

- **Death rates from heart disease and stroke have dropped dramatically** since their peak in the late 1960s (see Figure 1), with approximately half of the decline in heart disease deaths due to reductions in the burden of risk factors (e.g., smoking, high cholesterol, high blood pressure) through lifestyle and medications.[38]
- The **concept of cardiovascular disease risk factors** has become an integral part of the modern medical curriculum and has led to the development of effective treatment and preventive strategies in clinical practice.
- The Merck Manual's Centennial Edition listed Framingham as fourth among the 100 **most significant advances in 20th-century medicine**, behind only the development of antibiotics, mass immunization, and the discovery of vitamins.[39]

Age-Adjusted Death Rates for Coronary Heart Disease

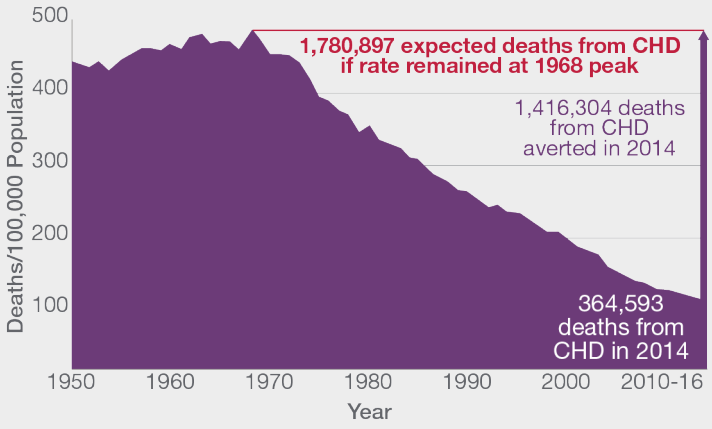


Figure 1: The age-adjusted death rates for coronary heart disease (CHD) have been dropping steadily since 1968. If they had remained at the 1968 peak levels, more than 1 million more heart disease deaths would have occurred by 2014. Source: National Vital Statistics Reports, CDC National Center for Health Statistics.[40]

SOCIETY

- Increased U.S. life expectancy due to progress against heart disease from 1970 to 2000 has added an estimated $1.6 trillion per year to national wealth.[42]
- About 90% of the observed gains in U.S. life expectancy have been credited to declines in the rates of death in infancy and from cardiovascular disease.[43]
- Unusual for the time, more than half of the original Framingham cohort were women. Because of this, we now appreciate that heart disease is not just a man's disease, as many originally thought.

KNOWLEDGE

- Findings from Framingham have informed our understanding of how cardiovascular health affects the rest of the body, especially how changes in blood flow to the brain can affect cognitive and neurological conditions.
- As of 2017, more than 3,500 articles based on Framingham research have been published since 1950 (Figure 2). While many publications are focused on cardiovascular disease, Framingham has also informed our understanding of obesity, diabetes, dementia, Parkinson's disease, osteoporosis, chronic obstructive pulmonary disease, and even cancer.[44]
- The success of Framingham made it a model for later prospective cohort studies, and epidemiologic tools and methodologies first developed by Framingham scientists are now commonly applied to understand chronic disease.
- Framingham led the way in scientific data sharing, from early data tables that were made freely available to other researchers in the 1960s[13] to the wealth of genetic information available today in the database of Genotypes and Phenotypes (dbGaP) and phenotype data in the NHLBI Biologic Specimen and Data Repository Information Coordinating Center (BioLINCC).[45] Investigators may also apply directly to the Framingham Heart Study to propose ancillary studies and access biospecimens.[46]

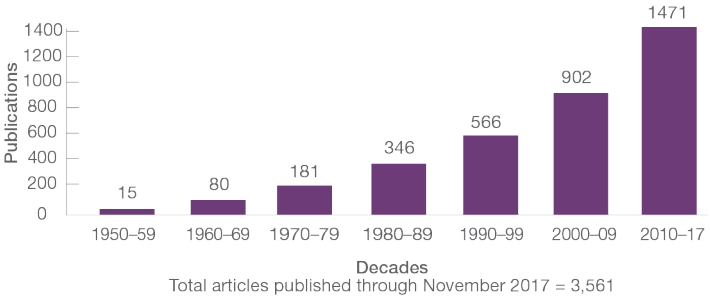


Figure 2: The number of publications coming from the Framingham Heart Study has risen dramatically every decade since the 1950s, demonstrating the study's ongoing and ever-increasing contributions to scientific and medical knowledge.

THE FRAMINGHAM RISK SCORE

The statistical methods developed by Framingham investigators allowed for better estimation of the effects of risk factors on the development of a complex chronic disease.[41] In 1998, in the most cited paper in Framingham history, this community-based epidemiologic information was then applied in order to predict an individual's 10-year risk of coronary heart disease, taking into account age, sex, smoking, diabetes, blood pressure, and cholesterol levels. The Framingham risk calculator, which in many ways changed the practice of medicine, has been refined over the years to include other risk factors, and a suite of additional risk calculators based on Framingham research are now available for heart disease, heart failure, atrial fibrillation, claudication (exercise-induced leg cramping), stroke, diabetes, high blood pressure, and more. Risk calculators tailored to different populations have also been developed.[40]

FRAMINGHAM INTO THE FUTURE

Despite progress against heart disease and stroke, cardiovascular disease remains the leading cause of death in the U.S. and globally.[47] Thanks to Framingham and other studies, we now know that most cardiovascular disease is caused by modifiable risk factors like smoking, high blood pressure, obesity, high cholesterol levels, and physical inactivity. As America faces a rising burden of chronic disease, Framingham has provided key insights into combatting them, equipping researchers and clinicians with a better understanding of how risk factors contribute to the development of such diseases. The Framingham Heart Study continues to lead cutting-edge research areas such as genomic, proteomic, and metabolomic biomarkers of cardiovascular disease risk, vascular stiffness, gut microbiome, and cardiopulmonary exercise testing, among others. Even as the Framingham Heart Study turns 70 years old, lessons learned, both old and new, continue to inform not only the way we study health and disease, but also our understanding of who is vulnerable to chronic diseases and why.

For references, supplementary information, and more on the impact of NIH, please visit **http://www.nih.gov/impact**