The impact of risk factors can be summarized in a quantitative way to provide a multivariate assessment of an individual’s probability of a stroke in a specified time period, usually 10 years. Multivariable risk factor modeling really was begun in Framingham in the 1960s and evolved to the present. Specific risk profiles for a number of cardiovascular disease (CVD) outcomes can be found at www.framinghamheartstudy.org, including the stroke risk profile published in 1991 with a modification for antihypertensive medication interaction in women.

The ability to synthesize and summarize in a quantitative manner the additive impact of an array of CVD risk factors provides a way to identify persons at substantial elevated risk even if they have multiple borderline or slightly elevated risk factor levels. These persons whose significantly increased probability of stroke (or CVD) might well be overlooked by a casual review of each risk factor level. When the precise levels are entered into the age- and sex-specific multivariate models it becomes apparent the patient is at moderate to high risk. These individuals with multiple borderline risk factor levels are not rare. The increased probability of a stroke (or CVD) often comes as an unexpected surprise to both patient and physician.

The Framingham Stroke Risk Profile (FSRP) consists of significant risk factors easily available to a practicing physician based on measurements obtained during an outpatient office visit (Figure 1). This gender-specific profile includes: age; systolic blood pressure (mm Hg); antihypertensive therapy; diabetes; cigarette smoking; presence of CVD (coronary heart disease, peripheral vascular disease, congestive heart failure); atrial fibrillation; and left ventricular hypertrophy by ECG. The FSRP has been widely used and is transportable to other populations in the United States, Europe, and Israel. The FSRP has been shown to provide valid probability predictions for stroke probability in a population in the Netherlands, although there was an overestimation of stroke risk in the upper range. The FSRP is comparable in composition and predictive value to the risk profiles developed in other prospective epidemiological studies of CVD such as the Cardiovascular Health Study (CHS) and the Atherosclerosis Risk in Communities (ARIC) in the United States. Framingham coronary heart disease (CHD) risk scores have also been shown to be valid in other ethnic groups after recalibration for differing prevalences of risk factors and event rates. The FSRP has validity in predicting a graded decrease in total brain volumes in the Framingham Offspring cohort on quantitative brain MRI (Figure 2) and on carotid intimal medial thickness in a French cohort.

Over the decades since the original FSRP was developed based on the FHS Original cohort risk factors in 1968 and 1978, both the prevalence and impact of the various risk factors have changed and stroke incidence has fallen. These changes, and the identification of more recently recognized risk factors for stroke necessitate modification of the FSRP to include newer data. The importance of family history of stroke and several risk markers such as C-reactive protein level have been recognized as significant contributors to stroke risk. More recently, other newer biomarkers have been identified, and genetic markers have been suggested as ways of improving the risk prediction models. In addition, determining the added predictive ability of a new marker has provided challenges as more novel measures and risk factors have been identified. Recently, assessment of the contribution to improved risk prediction by newer markers has stimulated examination of optimal statistical techniques for these evaluations.

Figure 1. Probability of stroke in 10 years in men and women age 70 years at systolic blood pressure of 160 mm Hg and the presence of other risk factors.

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Figure 2. Brain volume on brain MR scan as a percent of cranial volume according to quartiles of 10 year stroke risk probability.

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References

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