

## New Strategy to Reduce the Global Burden of Stroke

Valery L. Feigin, MD, PhD; Rita Krishnamurthi, PhD; Rohit Bhattacharjee, MPH; Priya Parmar, MSc; Alice Theadom, PhD; Tasleem Hussein, BSc; Mitali Purohit, MBioEnt; Patria Hume, PhD; Max Abbott, PhD; Elaine Rush, PhD; Nikola Kasabov, PhD; Ineke Crezee, PhD; Stanley Frielick, PhD; Suzanne Barker-Collo, PhD; P. Alan Barber, MD, PhD; Bruce Arroll, MBChB, PhD; Richie Poulton, PhD; Yogini Ratnasabath, MD, MSc; Martin Tobias, MBBCh; Norberto Cabral, MD, MSc, PhD; Sheila C.O. Martins, MD, PhD; Luis E.T.A. Furtado, MD; Patrice Lindsay, PhD; Gustavo Saposnik, MD, MSc; Maurice Giroud, MD, PhD; Yannick Béjot, MD, PhD; Werner Hacke, MD, PhD; Man Mohan Mehndiratta, MD, DM; Jeyaraj Durai Pandian, MD, DM; Sanjeev Gupta, MPT (MS), BPT; Vasantha Padma, MD; Dipes Kumar Mandal, MD, DM; Yoshihiro Kokubo, MD, PhD; Norlinah Mohamed Ibrahim, MBBCh, MRCP; Ramesh Sahathevan, PhD; Hua Fu, MB, PhD; Wenzhi Wang, PhD; Liping Liu, MD; Zeng-Guang Hou, PhD; António Freire Goncalves, MD, PhD; Manuel Correia, MD; Yury Varakin, MD, PhD; Michael Kravchenko, PhD; Michael Piradov, MD, PhD; Mohammed Saadah, MD; Amanda G. Thrift, PhD; Dominique Cadilhac, PhD; Stephen Davis, MD, PhD; Geoffrey Donnan, MD, PhD; Alan D. Lopez, PhD; Graeme J. Hankey, MD, PhD; Annick Maujean, PhD; Elizabeth Kendall, PhD; Michael Brainin, MD; Foad Abd-Allah, MD; Natan M. Bornstein, MD; Valeria Caso, MD, PhD; Juan Manuel Marquez-Romero, MD, MSc; Rufus O. Akinyemi, PhD; Nasser F. Bin Dhim, PhD; Bo Norrving, MD; Shireen Sindi, PhD; Miia Kivipelto, MD, PhD; Shanthi Mendis, PhD; M. Arfan Ikram, MD, PhD; Albert Hofman, MD, PhD; Saira Saeed Mirza, MD, MSc; Peter M. Rothwell, FMedSci; Peter Sandercock, MA, DM; Raad Shakir, MD; Ralph L. Sacco, MD, MS; Antonio Culebras, MD; Gregory A. Roth, MD, MPH; Maziar Moradi-Lakeh, MD, MPH; Christopher Murray, PhD; K.M. Venkat Narayan, MD; George A. Mensah, MD; David Wiebers, MD, PhD; Andrew E. Moran, MD; RIBURST Study Collaboration Writing Group

Received February 22, 2015; final revision received March 26, 2015; accepted March 27, 2015.

From the National Institute for Stroke and Applied Neurosciences, School of Public Health and Psychosocial Studies (V.L.F., R.K., R.B., P.P., A.T.), Faculty of Health and Environmental Sciences (P.H., M.A., E.R.), Information Technology (T.H.), Research and Innovation Office (M.P.), Knowledge Engineering and Discovery Research Institute (N.K.), Translation and Interpreting Department (I.C.), and Centre for Learning and Teaching (S.F.), Auckland University of Technology, Auckland, New Zealand; School of Psychology, University of Auckland, Auckland, New Zealand (S.B.-C.); Department of Neurology, University of Auckland, Auckland, New Zealand (P.A.B.); School of Public Health, University of Auckland, Auckland, New Zealand (B.A.); Department of Preventive and Social Medicine, Otago University, Dunedin, New Zealand (R.P.); Older People Care, Waitemata DHB, Auckland, New Zealand (Y.R.); Health Intelligence, Ministry of Health, Wellington, New Zealand (M.T.); Joinville Stroke Register, University of Joinville Region, Joinville, Brazil (N.C.); Hospital de Clinicas de Porto Alegre, Hospital Moinhos de Vento, Ministry of Health, Brazil (S.C.O.M.); Department of Neurology, Universidade Federal do Ceará, Sobral-Ceará, Brazil (L.E.T.A.F.); Stroke Foundation of Canada, Ottawa, Canada (P.L.); Department of Medicine and Health Policy, Management and Evaluation University of Toronto, Toronto, Canada (G.S.); Dijon Stroke Registry, EA4184, University Hospital and Medical School of Dijon, University of Burgundy, Dijon, France (M.G., Y.B.); Department of Neurology, Ruprecht Karl University Heidelberg, Heidelberg, Germany (W.H.); Janakpuri Super Speciality Hospital, New Delhi, India (M.M.M.); Department of Neurology, Christian Medical College, Ludhiana, Punjab, India (J.D.P.); Banarsidas Chandiwal Institute of Physiotherapy, Kalkaji, New Delhi, India (S.G.); All India Institute of Medical Sciences, New Delhi, India (V.P.); Stroke Foundation of Bengal, Kolkata, West Bengal, India (D.K.M.); Department of Preventive Cardiology, National Cerebral and Cardiovascular Center, Osaka, Japan (Y.K.); UKM Medical Center, Kuala Lumpur, Malaysia (N.M.I., R.S.); School of Public Health, Fudan University, Shanghai, China (H.F.); Beijing Neurosurgical Institute, Beijing, China (W.W.); Capital Medical University, Beijing, China (L.L.); Institute of Automation, Beijing, China (Z.-G.H.); University Hospital of Coimbra, Coimbra, Portugal (A.F.G.); Serviço de Neurologia, Hospital de Santo António, Portugal (M.C.); Research Center of Neurology, Moscow, Russia (Y.V., M.K., M.P.); University of Emirates, Abu Dhabi, United Arab Emirates (M.S.); Department of Medicine, Monash University, Clayton, Victoria, Australia (A.G.T., D.C.); The Royal Melbourne Hospital (S.D.); Florey Institute of Neuroscience and Mental Health (G.D.), and Public Health (A.D.L.), University of Melbourne, Parkville, Australia; School of Medicine and Pharmacology, University of Western Australia, Perth, Australia (G.J.H.); Griffith University, Brisbane, Australia (A.M., E.K.); Center for Clinical Neurosciences, Danube University, Vienna, Austria (M.B.); Cairo University, Cairo, Egypt (F.A.-A.); Tel Aviv Sourasky Medical Center, Neurology Department, Tel Aviv University, Tel Aviv, Israel (N.M.B.); Stroke Unit, Perugia, Italy (V.C.); HGZ 2, IMSS Aguascalientes, Aguascalientes, Mexico (J.M.M.-R.); Federal Medical (Stroke. 2015;46:1740-1747. DOI: 10.1161/STROKEAHA.115.008222.)

© 2015 American Heart Association, Inc.

Stroke is available at <http://stroke.ahajournals.org>

DOI: 10.1161/STROKEAHA.115.008222

## Increasing Global Stroke Burden

The socioeconomic and health effect of stroke and other non-communicable disorders (NCDs) that share many of the same risk factors with stroke, such as heart attack, dementia, and diabetes mellitus, is huge and increasing.<sup>1-4</sup> Collectively, NCDs account for 34.5 million deaths (66% of deaths from all causes)<sup>3</sup> and 1344 million disability-adjusted life years lost worldwide in 2010.<sup>2</sup> The burden of NCDs is likely to burgeon given the aging of the world's population and the epidemiological transition currently observed in many low- to middle-income countries (LMICs).<sup>5,6</sup> In addition, there is low awareness in the population about these NCDs and their risk factors,<sup>7-10</sup> particularly in LMICs.<sup>11</sup> These factors, coupled with underuse of strategies for primary prevention of stroke/NCDs on an individual level and the lack of accurate data on the prevalence and effect of risk factors in different countries and populations have been implicated in the ever-increasing worldwide burden of the NCDs.<sup>12-15</sup> Of particular concern is a significant increase in the number of young adults (aged <65 years) affected by stroke,<sup>16</sup> and the increasing epidemic of overweight/obesity<sup>17</sup> and diabetes mellitus worldwide.<sup>18</sup> If these trends continue, the burden of stroke and other major NCDs will increase even faster. The increasing burden of stroke and other major NCDs provide strong support for the notion that the currently used primary prevention strategies for stroke and other major NCDs (business as usual) are not sufficiently effective. The most pertinent solution to this problem is the implementation of new, effective, widely available, and cost-effective prevention and treatment strategies to reduce the incidence and severity distribution of stroke and other major NCDs.

## Issues With Population-Wide Prevention Strategies

The recent INTERSTROKE case-control study, conducted in 22 countries worldwide, provided evidence that, collectively, 10 risk factors accounted for 88.1% (99% confidence interval, 82.3%–92.2%) of the population-attributable risk for all stroke.<sup>19</sup> Because many (but not all) of these risk factors are modifiable, the INTERSTROKE data suggest that interventions that reduce blood pressure, promote physical activity, smoking cessation, and a healthy diet, could substantially reduce the burden of stroke. Although a combination of population-wide and

individual high-risk prevention strategies were initially advocated >30 years ago,<sup>20</sup> and have since been repeatedly recommended as the most promising strategies to reduce stroke and NCDs burden, there is still no country in the world where both these prevention strategies have been implemented in full. There are major hurdles to implementing population-wide primary prevention strategies, including the need for policy and legislative changes that are often not supported by major industries (such as salt reduction in processed food, reduction of exposure to cigarette smoking, alcohol, and fast food). In addition, there are significant costs associated with the implementation of some of these strategies (eg, availability and accessibility of facilities for sport and physical activity, healthy food outlets). However, there are some regions (eg, North Karelia, Finland; Franklin County, USA; and Japan) where implementation of some elements of these preventative strategies have proven highly effective at the community level.<sup>21-23</sup>

## Global Burden of Risk Factors for Stroke

The Global Burden of Diseases 2010 studies found that the 3 leading risk factors for disease burden were high blood pressure, tobacco smoking (including second-hand smoke), and alcohol use.<sup>24</sup> Moreover, these 3 risk factors were ranked in the top 3 for several low- to middle-income regions, including Central and Eastern Europe, Southern Latin America, and Central Asia. In addition, lifestyle factors, such as high sodium, low fruit diets, and physical inactivity contributed to 10% of disability-adjusted life years in 2010. These risk factors, along with the nonmodifiable factors of age, sex, and ethnicity, contribute significantly to stroke incidence.<sup>19</sup> A national survey estimated the prevalence of high blood pressure in China to be 29.6%, whereas a systematic review estimated the overall prevalence in India at 29.8%.<sup>25,26</sup> High blood pressure is the most potent risk factor for stroke and the current and rising prevalence rates of this risk factor alone will contribute significantly to stroke burden globally. Given that nearly 70% incident stroke occur in LMICs,<sup>16</sup> health policies to reduce the prevalence of these risk factors is crucial.

## Issues With High-Risk Prevention Strategies

High-risk prevention strategies are currently based on the identification and management of subjects with high absolute risk

---

Centre Abeokuta, Abeokuta, Nigeria (R.O.A.); Health Informatics Department, Saudi Electronic University, Saudi Arabia (N.F.B.D.); Department of Neurology, Lund University, Lund, Sweden (B.N.); Department of Epidemiology (S.S.) and Aging Research Center, Center for Alzheimer Research (M.K.), Karolinska Institutet, Stockholm, Sweden; Noncommunicable Diseases, World Health Organization, Geneva, Switzerland (S.M.); Erasmus University Medical Center, Rotterdam, The Netherlands (M.A.I., A.H., S.S.M.); Nuffield Department of Neuroscience, Oxford University, Oxford, United Kingdom (P.M.R.); Western General Hospital, Edinburgh, United Kingdom (P.S.); Department of Neurology, Imperial College NHS Trust, London, United Kingdom (R.S.); Department of Neurology, Miller School of Medicine, University of Miami (R.L.S.); Department of Neurology, SUNY Upstate Medical University, Syracuse, NY (A.C.); Division of Cardiology, Department of Medicine (G.A.R.), Institute for Health Metrics and Evaluation (G.A.R., M.M.-L., C.M.), University of Washington, Seattle; Emory University, Atlanta, GA (K.M.V.N.); Center for Translation Research and Implementation Science, National Heart, Lung, and Blood Institute, National Institutes of Health, Bethesda, MD (G.A.M.); Department of Neurology, Mayo Clinic, Rochester, MN (D.W.); and Division of General Medicine, Columbia University Medical Center, NY (A.E.M.).

The views expressed in this article are those of the authors and do not necessarily represent the views of the National Heart, Lung, and Blood Institute, National Institutes of Health, or the US Department of Health and Human Service.

This article is based on Lecture of Excellence presentation "New horizons for stroke prevention" given by Prof. Valery L. Feigin at the 9th World Stroke Congress in Istanbul, Turkey, October 24, 2014.

**The online-only Data Supplement is available with this article at <http://stroke.ahajournals.org/lookup/suppl/doi:10.1161/STROKEAHA.115.008222/-DC1>.**

Correspondence to Valery L. Feigin, MD, MSc, PhD, National Institute for Stroke and Applied Neurosciences, School of Public Health and Psychosocial Studies, Faculty of Health and Environmental Sciences, Auckland University of Technology, AUT North Shore Campus, AA254, 90 Akoranga Dr, Northcote 0627, Private Bag 92006, Auckland 1142, New Zealand. E-mail [valery.feigin@aut.ac.nz](mailto:valery.feigin@aut.ac.nz)

of acute cardiovascular disease (CVD) occurrence, such as in those with heart attack, stroke, and acute peripheral artery disease.<sup>27–29</sup> This high absolute risk of CVD is usually defined as a risk of  $\geq 15\%$  during the next 5 years.<sup>27</sup> This approach is valid and suitable for selecting people at high risk of acute CVD and for monitoring their progress in CVD prevention in the outpatient setting. However, in terms of effective primary stroke/CVD prevention, there are several issues with this approach. First and foremost, although there are well-recognized management strategies for prevention of stroke, transient ischemic attack, and other NCDs,<sup>30</sup> these strategies are primarily targeted at high-risk individuals that represent a small proportion of those who will go on to have a stroke.<sup>31,32</sup> Given that the majority of strokes in the population occur in those with mildly elevated stroke risk, population-wide reduction strategies aimed at all levels of stroke risk would improve the effectiveness of these campaigns. In addition, clinical experience shows that an unintended consequence of risk assessment is that people who are told by a doctor they are at low ( $<5\%$ ) and moderate ( $5\%$  to  $14\%$ ) 5-year risk of CVD occurrence are not motivated enough to do anything to control their risk factors because they think they are not at high risk of CVD. Second, calculation of absolute risk based on most CVD prediction algorithms used, often requires additional laboratory tests (eg, for determination of the level of blood cholesterol or glucose). Determining the risk of stroke/CVD also usually requires a visit to a health professional or an outpatient clinic. The time and costs associated with these arrangements may be a deterrent for many individuals, particularly those who are socioeconomically disadvantaged or live in remote rural communities. Third, even in high-income countries, the use of high-risk CVD prevention strategies by medical professionals is poor<sup>27</sup> as is the adherence of patients to the recommended medications and lifestyle for primary and secondary CVD prevention.<sup>33</sup> Fourth, the tools that are commonly used to predict the risk of stroke/CVD<sup>34,35</sup> are not easily accessible in multiple languages, not aimed at younger age groups ( $<55$  years), do not account for racial/ethnic and geographical differences, or are designed for use by health professionals only. Therefore, people who do not fall into the high-risk category will not usually have access to this information, and are consequently unable to take the remedial steps necessary to minimize their likelihood of having a stroke in the future. Finally, CVD prediction algorithms used for calculating the risk are usually based on the Framingham Study<sup>34,36</sup> and have several major limitations.<sup>37</sup> The Framingham Study was based on a selective group of primarily white Americans aged  $>55$  years and, therefore, the Framingham algorithm for CVD prediction may not be applicable to all populations. In addition, many risk factors recently demonstrated to be important for CVD occurrence (eg, diet, physical activity, overweight, race/ethnicity, etc.) were not included in the Framingham Study CVD prediction algorithm. These limitations have resulted in the American Heart Association and the American College of Cardiology in 2013 no longer recommending the use of the Framingham Study algorithm for individual risk prediction of coronary heart disease in the United States.<sup>38</sup> However, the American Heart Association/American Stroke Association still recommends the use of the Framingham stroke prediction algorithm as a risk-assessment tool for primary stroke prevention.<sup>30</sup>

## Gaps in Knowledge

Reliable data on the frequency, distribution and determinants of stroke, and other major NCDs in most countries of the world are lacking,<sup>3,16,36</sup> although modeling performed for the Global Burden of Disease project has provided estimates for some.<sup>3,16,17,24,39</sup> This information is crucial for developing global and country-specific and culturally tailored evidence-based recommendations on the prevention and care of stroke and other major NCDs. In addition, although compelling evidence exists that increasing population/country-specific knowledge about stroke warning signs and risk factors can reduce stroke burden in the population,<sup>40–42</sup> the uptake of this knowledge is poor in most countries. This poor uptake of knowledge is particularly the case in older adults ( $65+$ ),<sup>7,43</sup> minority ethnic groups,<sup>7,44,45</sup> people with poor educational attainment,<sup>7</sup> and rural dwellers.<sup>46</sup> The lack of epidemiological data on stroke and other NCDs in most countries is chiefly because of the high costs associated with conducting conventional, ideal population-based studies on NCDs incidence, prevalence, and risk factors because they usually require coverage of the large study populations/areas, face-to-face contacts with study participants or postal/telephone interviews. In addition, there is often a lack of local expertise and experience to properly design and conduct such studies.

## New and Promising Strategy for Primary Stroke Prevention

Recent advances in smartphone technologies, including high processing power, storage, constant internet connection, personalized notification methods, growing worldwide uptake, and proximity to the users, offer unique opportunities to use these technologies for improving health and enhancing research capabilities. Importantly, easily accessible and cost-effective risk-estimation systems are well suited to the developing world and other regions where access to medical facilities is limited,<sup>37</sup> including elderly populations where smartphones are being increasingly used.<sup>47–49</sup> A recent systematic review<sup>50</sup> showed that mobile phone-based technology in LMICs positively affects the chronic disease management and their clinical outcomes.

There are numerous stroke and other NCDs smartphone applications (apps) currently available in the Apple Store and Google Play. There are also several smartphone-based technologies and apps that were, or are, being used in clinical trials for managing particular medical conditions and risk factors (eg, smoking cessation, depression, weight, and asthma management),<sup>51–54</sup> with promising results. Despite this, few apps are based on evidence-based prediction algorithms, and even fewer have sufficient validity to be used for research data collection. As far as we are aware, there is no app designed to provide not only educational information but also to collect valid data to measure and reduce the burden of NCDs worldwide. In recognition of the importance of e-research NCDs initiatives, the United Nations Economic and Social Council, the International Telecommunication Union, and the World Health Organization in June 2013 launched a new mHealth initiative for improving NCDs prevention, treatment, and policy enforcement.<sup>55</sup>

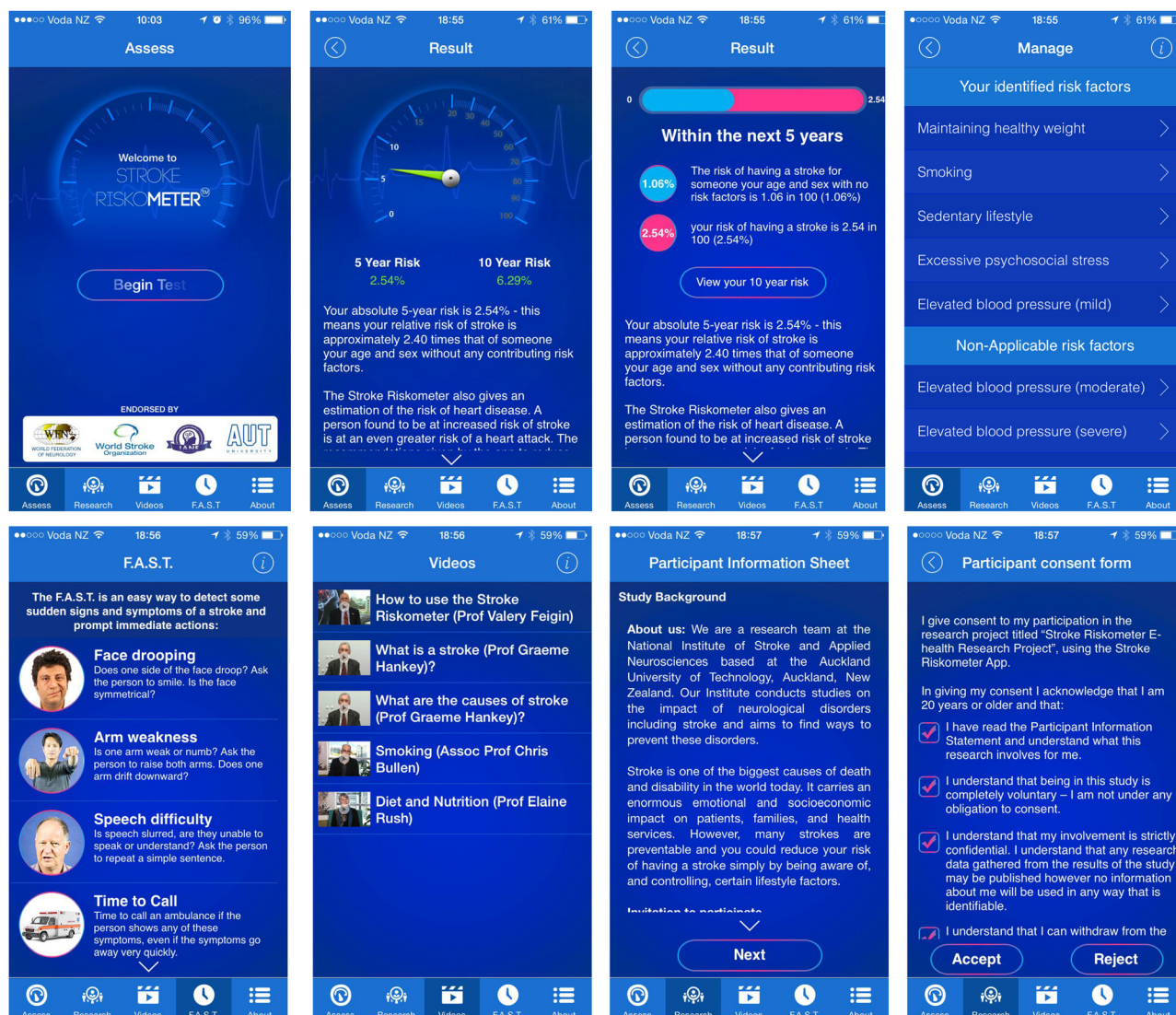


To inform and support these United Nations/International Telecommunication Union/World Health Organization efforts (including World Health Organization Global NCD Action Plan for 2013–2020),<sup>4,56</sup> to increase general awareness about stroke and its risk factors, and to improve stroke and heart attack prevention on an individual level, the National Institute for Stroke and Applied Neurosciences, The Faculty of Health and Environmental Sciences, Auckland University of Technology (AUT) in collaboration with AUT Enterprises Ltd of AUT University and The NZ Stroke Education (charitable) Trust recently developed an app called the Stroke Riskometer App (Figure 1).<sup>57</sup> The Stroke Riskometer App calculates the 5-year and 10-year risk of stroke for any individual aged  $\geq 20$  years, based on their responses to a short questionnaire. Full details of the app have been described in detail elsewhere<sup>58</sup> and are briefly described in Table I in the online-only Data Supplement.

The majority of these additional risk factors were identified as being important predictors of stroke by the INTERSTROKE investigators,<sup>19</sup> and serve to strengthen the accuracy and

reliability of the prediction algorithm used in the app. The Stroke Riskometer algorithm has been validated<sup>58</sup> and found to be comparable with the Framingham and QSTROKE stroke risk prevention algorithms commonly used in medical practice. Notably, as well as absolute risk, the app also provides users with their relative risk of having a stroke compared with someone of the same age and sex who does not have any risk factors at all. We think this is a significant additional preventative strategy because it may draw the attention of those with a relatively low absolute risk to their nevertheless increased relative risk, thereby motivating them to control their risk factors. This approach has been recognized as a new paradigm in primary stroke prevention.<sup>15</sup>

The app has a section to educate people about stroke warning symptoms and signs and what to do if any of these symptoms/signs occur. This section uses the face, arm, speech, time message, a strategy shown to be effective in reducing the time to hospitalization.<sup>41</sup> In addition, users have an option to e-mail their stroke risk assessment results to a person of their choice and they also have an option of sharing their experience of



**Figure 1.** Example of screenshots of Stroke Riskometer App. F.A.S.T. indicates face, arm, speech, time. Images from Stroke Riskometer Lite and Pro with permission from AUT Enterprises Limited.

using the app via social media. Preliminary evidence suggests that the app is appealing to individuals concerned because it empowers them to know and self-manage their risk and risk factors. Regular and wide use of this app could be as efficient as the conventional population-based approach because it allows identification and engagement in prevention of all individuals who are at even slightly increased risk of stroke and CVD. We also encourage health professionals to use the app in their everyday practice.

There are 2 versions of the Stroke Riskometer App, Lite and Pro. Stroke Riskometer Lite version has been endorsed by the World Stroke Organization. The World Federation of Neurology and the International Association of Neurology and Epidemiology have endorsed both versions of the Stroke Riskometer App. The smartphone-based platform means that the potential reach of this app is enormous. With  $\approx 1.75$  billion people in the world owning smartphones,<sup>59</sup> people across the globe will have easy access to their stroke risk and risk factors in their own language. Prediction of stroke risk can also be performed for family members, such as parents (who may not own a Smartphone), using one device. To be accessible to as many people as possible, the Stroke Riskometer App is being translated into 11 most commonly spoken languages (Mandarin, Hindi, Spanish, Russian, Arabic, Bengali, Portuguese, Malay, French, German, and Japanese; Table II in the online-only Data Supplement lists the editors of the translated versions) covering >160 countries ( $\approx 5.6$  billion people).

### New Promising Approach to Epidemiological Research of NCDs

We think that the Stroke Riskometer App represents an important tool in spreading awareness about stroke, its risk factors and how to tackle them, and, if leveraged correctly, could also represent a significant breakthrough as a method of conducting epidemiological research in NCDs internationally. The mobile app-based platform provides a cost-effective means to collect data from potential study participants on a global scale that is not possible with conventional (and costly) prospective population-based research methods. The latest update to the Stroke Riskometer App includes a research section that allows users to participate in a cross-sectional study followed by a longitudinal cohort study (initially >12 months, and with the potential to extend follow-up during a longer timeframe). The study will be conducted in 5 phases as outlined in Table. This study, titled Reducing the International Burden of Stroke Using Mobile Technology (RIBURST) involves >160 countries (Figure 2). Although the Stroke Riskometer App users will be under no obligation to do so, they will have the ability to voluntarily consent into the Stroke Riskometer-based RIBURST study via the app, and their results will be encrypted and stored in a secure database at AUT University. They will be reminded to redo the questionnaire after 12 months via push notifications and e-mail prompts. Push notification is one of the smartphone unique advantages that allows the research database to send messages to a specific user's device (similar to mobile short message service) at specified time, or after a specific task, free of cost, and offer more privacy than short message service.<sup>60</sup> This information will be sent through to

**Table. Phases of the Reducing the International Burden of Stroke Using Mobile Technology Study**

First phase (2015–2016): To evaluate the prevalence of stroke, heart attack, type 2 diabetes mellitus, traumatic brain injury, and dementia and their risk factors in different countries and demographic groups worldwide

Second phase (2016–2017): To determine an etiologic role of lifestyle, environmental, sociodemographic, and pathophysiological factors in the occurrence of stroke, heart attack, type 2 diabetes mellitus, and dementia, with an emphasis on modifiable risk factors, with assessments initially conducted at 12 mo follow-up

Third Phase (2018): To develop specific algorithms (and associated Apps) for prediction of stroke, heart attack, type 2 diabetes mellitus, and dementia for specific countries/populations

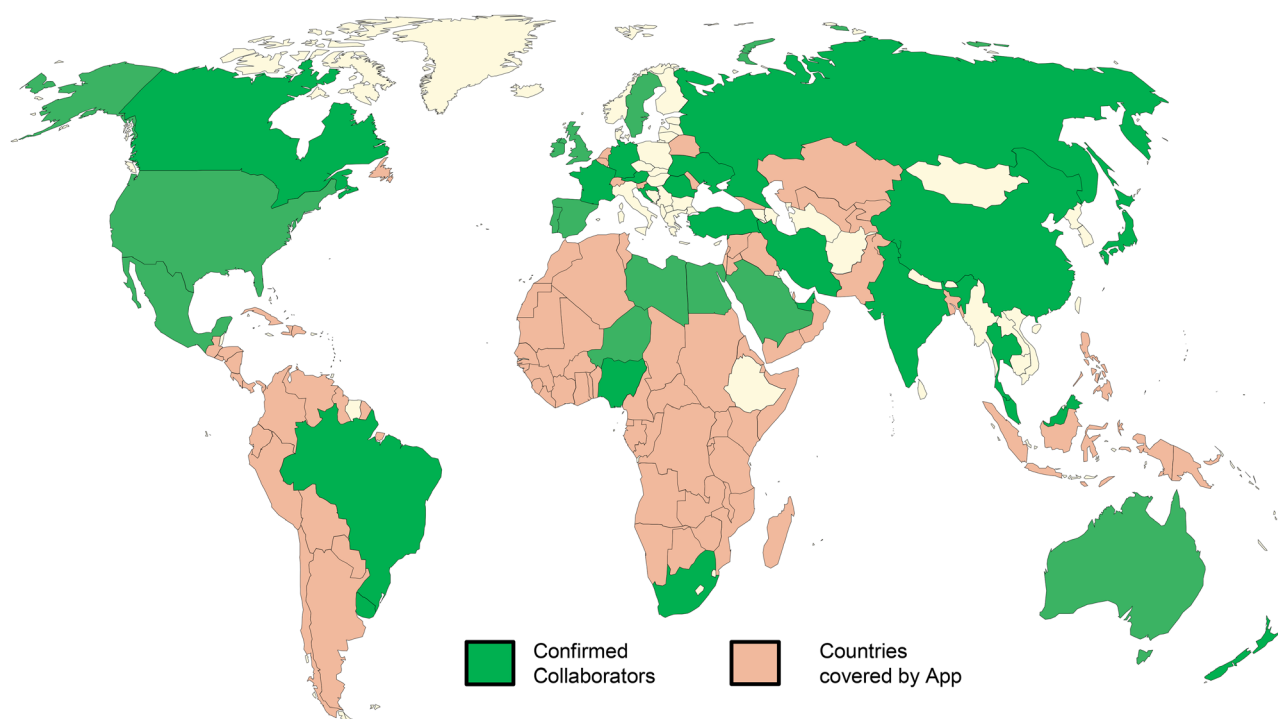
Fourth Phase (2019–2024): To develop and test in an randomized controlled trial setting culturally appropriate smartphone-based interventions (namely cognitive-behavioral) for primary prevention of stroke, heart attack, type 2 diabetes mellitus, and dementia

Fifth Phase (2025): To update/implement country-specific Apps for primary NCDs prevention

NCD indicates noncommunicable disorder.

the secure AUT database, and compared with the participant's baseline results. The Stroke Riskometer is also available in a Website format to offer the users many options to access and use the assessment tool and participate in the research study. The Website is also available commercially to governments and other organizations, such as hospitals, health and wellness clinics, and stroke foundations internationally, to allow integration of the assessment into their daily practice. The Auckland University of Technology Ethics Committee has approved the RIBURST study (reference number 14/201).

We also plan to use our findings for individual risk prediction (using the spiking neural network approach) of stroke, and other NCDs.<sup>61</sup> Promoting participation in the Stroke Riskometer-based studies will have at least 2 major benefits. First, it could provide unprecedented patient-generated evidence about the frequency, prevalence and determinants of stroke, heart attack, dementia, and diabetes mellitus, in various countries and populations worldwide. This will serve to fill the gap in knowledge about these NCDs in many countries of the world, especially in LMIC. Second, it will allow the research team to evaluate the accuracy of the algorithm, and the research data collected will facilitate further fine-tuning to improve the prediction formula for stroke, as well as for heart attack, dementia, and diabetes mellitus. On the basis of this information, future versions of the app will have greater accuracy in calculating the risk of stroke and other major NCDs, such as for specific countries/regions and ethnic/racial groups. One additional outcome of such studies could be an improvement in the overall management of stroke risk factors by practicing health professionals and in the time to achieve management goals. In addition, the intention is to share information collected from different countries with local and regional collaborators to contribute to suitable action plans to tackle the burden of NCDs in their country/regions. We also intend to work with regional collaborators to analyze and disseminate local and regional findings to assist with tackling the significant cost and burden associated with stroke and other major NCDs. To ensure participant privacy, all data will be



**Figure 2.** Map showing countries covered by the Reducing the International Burden of Stroke Using Mobile Technology Study (Remain to be Finalized).

stored on secure, encrypted servers. In addition, identifying details (such as names and e-mail addresses) will be stored in a separate database from the survey results (linked by a randomly generated unique identifier). All participants will have to consent to participating in the RIBURST study before any personal data are collected and stored by the researchers. For users not participating in the study, results may be saved locally on their devices, but there is no identifiable information stored within the app in these scenarios.

There are several potential limitations of the RIBURST study. One potential limitation is the question of the validity and accuracy of the recall-based responses, which is an important consideration in all self-reported research. To ensure the data collected for this research project is accurate, validation studies are planned where a random subset of participants across several countries will be approached for permission to cross-reference submitted responses with medical records. For consenting study participants in those countries, self-reported information on risk factors, health conditions, and NCDs outcomes (new NCDs events) for accuracy will be cross-checked with relevant information from the local national databases, general practitioner records or proven reliable household surveys<sup>62</sup> for validation (subject to additional ethics approvals from participating countries). A representation of the sample demographic characteristics to the country concerned will be ascertained, and only data from reasonably representative samples will be included in the analysis. We also acknowledge that our app, as any other app, has limitations that may limit its use in certain individuals (eg, people with severe disabilities, dementia, or visual deficit). However, our intention was to develop an app that could be used by the majority of the population, including people in LMICs.

This will allow generalization of the validated data to the whole population across various countries. Other limitations include the limited access to smartphones of the most socioeconomically disadvantaged groups and people with disabilities who may have difficulties using the app (including those who became disabled during the study), stopped using the app or died during the study. However, smartphones have become less expensive and thus more accessible to some socioeconomically disadvantaged groups. Quality control measures and statistical modeling techniques are being developed to minimize selection bias and impute missing follow-up information. For example, study participants are encouraged to provide an alternative contact person's e-mail address and if the study participant is not contactable or cannot complete the follow-up questionnaires for various reasons their alternative contact individual will be contacted and asked to complete the questionnaire for the study participant.

In summary, stroke and other major NCDs continue to be one of the most important health concerns on a global scale. Current prevention and intervention techniques are not effective enough in targeting individuals at low or moderate risk of stroke, these being the groups in whom the majority of strokes occur. New effective and affordable primary prevention strategies to reduce the burden of stroke and other major NCDs are urgently needed on a global scale. The Stroke Riskometer App uses the rapidly growing smartphone platform to provide individualized stroke risk assessments. It will be used to inform and educate a significant proportion of the global population about their risk of stroke and how to reduce it, and is likely to contribute to reducing the burden of stroke and other NCDs worldwide.



## Acknowledgments

The work was supported by the Research and Innovation Office, Faculty of Health and Environmental Sciences, Centre for Learning and Teaching and Auckland University of Technology (AUT) Enterprises Ltd at AUT University, Auckland, New Zealand. We also thank Helen McDonald (National Institute for Stroke and Applied Neurosciences, AUT University) for secretarial support. Dr Feigin developed the idea of the Stroke Riskometer App, designed the first version of the app, conceived the study, provided overall guidance, and wrote the first draft of the article; Drs Krishnamurthi and Feigin finalized the draft based on comments from other authors; P. Parmar developed statistical analysis plan; R. Bhattacharjee was primarily responsible for communication with the Stroke Riskometer App developers and contributed to the study design; T. Hussein was primarily responsible for the development of IT systems for study data collection and Website development and contributed to the design of the study; M. Purohit, S. Gupta, Drs Rush, Crezee, Barber, Theadom, Barker-Collo, Cabral, Martins, Furtado, Sahathevan, Fu, Wang, Ikram, Hofman, Mirza, Varakin, Kravchenko, Sindi, Kivipelto, Hankey, Saposnik, Giroud, Béjot, Mehndiratta, Pandian, Padma, Mandal, Kokubo, Bin Dhim, Goncalves, Correia, Thrift, Cadilhac, Davis, Lopez, Brainin, Hacke, Saadah, Norrving provided guidance on the methodology. All authors reviewed the article.

## Sources of Funding

This study was supported by Auckland University of Technology, Research and Innovation Office, Faculty of Health and Environmental Sciences, Centre for Learning and Teaching and Auckland University of Technology Enterprises Ltd at Auckland University of Technology, Auckland 1142, New Zealand and Kiwi Innovation Network Limited, Waikato Mail Centre, Hamilton, New Zealand.

## Disclosures

Coauthors from the Auckland University of Technology (R. Bhattacharjee, P. Parmar, T. Hussein, M. Purohit, Drs Feigin, Krishnamurthi, Theadom, Hume, Abbott, Rush, Kasabov, Crezee, and Frielick) declare that funds resulting from the sale of the professional version of the Stroke Riskometer App will be used for further research and education for stroke prevention. Dr Theadom, as a coinvestigator of incidence of stroke study in New Zealand, has received a research grant from Health Research Council. Dr Wang has received funding from the Wellcome Trust. Dr Saposnik has received a grant from the Heart and Stroke Foundation of Canada and is supported by the Distinguished clinician Scientific Award. Dr Mensah has received funding for research from the National Institutes of Health. Dr Hankey received honoraria from Bayer, Medscape, and the heart.org for his involvement in their symposia/educational program. The other authors report no conflicts.

## References

- Feigin VL, Forouzanfar MH, Krishnamurthi R, Mensah GA, Connor M, Bennett DA, et al. Global and regional burden of stroke in 1990–2010: findings from the Global Burden of Disease Study 2010. *Lancet*. 2013;382:1–12.
- Murray CJ, Vos T, Lozano R, Naghavi M, Flaxman AD, Michaud C, et al. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet*. 2012;380:2197–2223. doi: 10.1016/S0140-6736(12)61689-4.
- Lozano R, Naghavi M, Foreman K, Lim S, Shibuya K, Aboyans V, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet*. 2012;380:2095–2128. doi: 10.1016/S0140-6736(12)61728-0.
- Mendis S. Global status report on noncommunicable diseases 2014: World Health Organization. <http://www.who.int/global-coordination-mechanism/publications/global-status-report-ncds-2014-eng.pdf>. Accessed April 8, 2015.
- Cappuccio FP. Commentary: epidemiological transition, migration, and cardiovascular disease. *Int J Epidemiol*. 2004;33:387–388. doi: 10.1093/ije/dyh091.
- Akinyemi RO, Izzeldin IM, Dotchin C, Gray WK, Adeniji O, Seidi OA, et al. Contribution of noncommunicable diseases to medical admissions of elderly adults in Africa: a prospective, cross-sectional study in Nigeria, Sudan, and Tanzania. *J Am Geriatr Soc*. 2014;62:1460–1466. doi: 10.1111/jgs.12940.
- Jones SP, Jenkinson AJ, Leathley MJ, Watkins CL. Stroke knowledge and awareness: an integrative review of the evidence. *Age Ageing*. 2010;39:11–22. doi: 10.1093/ageing/afp196.
- Roberts JL, Clare L, Woods RT. Subjective memory complaints and awareness of memory functioning in mild cognitive impairment: a systematic review. *Dement Geriatr Cogn Disord*. 2009;28:95–109. doi: 10.1159/000234911.
- Matthaei S, Munro N, Zinman B. Raising diabetes awareness in the public domain. *Int J Clin Pract*. 2007;61:31–37.
- Li X, Fang W, Su N, Liu Y, Xiao S, Xiao Z. Survey in Shanghai communities: the public awareness of and attitude towards dementia. *Psychogeriatrics*. 2011;11:83–89. doi: 10.1111/j.1479-8301.2010.00349.x.
- Abd-Allah F, Moustafa RR. Burden of stroke in Egypt: current status and opportunities. *Int J Stroke*. 2014;9:1105–1108. doi: 10.1111/ijss.12313.
- Strong K, Mathers C, Bonita R. Preventing stroke: saving lives around the world. *Lancet Neurol*. 2007;6:182–187. doi: 10.1016/S1474-4422(07)70031-5.
- Kontis V, Mathers CD, Rehm J, Stevens GA, Shield KD, Bonita R, et al. Contribution of six risk factors to achieving the 25×25 non-communicable disease mortality reduction target: a modelling study. *Lancet*. 2014;384:427–437. doi: 10.1016/S0140-6736(14)60616-4.
- Sacco RL, Smith SC, Holmes D, Shurin S, Brawley O, Cazap E, et al. Accelerating progress on non-communicable diseases. *Lancet*. 2013;382:e4–e5. doi: 10.1016/S0140-6736(13)61477-3.
- Feigin VL, Norrving B. A new paradigm for primary prevention strategy in people with elevated risk of stroke. *Int J Stroke*. 2014;9:624–626. doi: 10.1111/ijss.12300.
- Feigin VL, Forouzanfar MH, Krishnamurthi R, Mensah GA, Connor M, Bennett DA, et al; Global Burden of Diseases, Injuries, and Risk Factors Study 2010 (GBD 2010) and the GBD Stroke Experts Group. Global and regional burden of stroke during 1990–2010: findings from the Global Burden of Disease Study 2010. *Lancet*. 2014;383:245–254.
- Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet*. 2014;384:766–781.
- Alberti KG, Zimmet P. Global burden of disease—where does diabetes mellitus fit in? *Nat Rev Endocrinol*. 2013;9:258–260. doi: 10.1038/nrendo.2013.54.
- O'Donnell MJ, Xavier D, Liu L, Zhang H, Chin SL, Rao-Melacini P, et al; INTERSTROKE investigators. Risk factors for ischaemic and intracerebral haemorrhagic stroke in 22 countries (the INTERSTROKE study): a case-control study. *Lancet*. 2010;376:112–123. doi: 10.1016/S0140-6736(10)60834-3.
- Rose G. Strategy of prevention: lessons from cardiovascular disease. *Br Med J (Clin Res Ed)*. 1981;282:1847–1851.
- Puska P. Successful prevention of non-communicable diseases: 25 Year experiences with North Karelia project in Finland. *Public Health Medicine*. 2002;4:5–7.
- Miura K. Epidemiology and prevention of hypertension in Japanese: how could Japan get longevity? *EPMA J*. 2011;2:59–64. doi: 10.1007/s13167-011-0069-y.
- Record NB, Onion DK, Prior RE, Dixon DC, Record SS, Fowler FL, et al. Community-wide cardiovascular disease prevention programs and health outcomes in a rural county, 1970–2010. *JAMA*. 2015;313:147–155. doi: 10.1001/jama.2014.16969.
- Lim SS, Vos T, Flaxman AD, Danaei G, Shibuya K, Adair-Rohani H, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet*. 2012;380:2224–2260. doi: 10.1016/S0140-6736(12)61766-8.
- Anchala R, Kannuri NK, Pant H, Khan H, Franco OH, Di Angelantonio E, et al. Hypertension in India: a systematic review and meta-analysis of prevalence, awareness, and control of hypertension. *J Hypertens*. 2014;32:1170–1177. doi: 10.1097/HJH.0000000000000146.
- Ke L, Ho J, Feng J, Mpofu E, Dibley MJ, Li Y, et al. Prevalence, awareness, treatment and control of hypertension in macau: results from a cross-sectional epidemiological study in Macau, China. *Am J Hypertens*. 2015;28:159–165. doi: 10.1093/ajh/hpu121.

27. Jansen J, Bonner C, McKinn S, Irwig L, Glasziou P, Doust J, et al. General practitioners' use of absolute risk versus individual risk factors in cardiovascular disease prevention: an experimental study. *BMJ Open*. 2014;4:e004812. doi: 10.1136/bmjopen-2014-004812.
28. Powles J, Shroufi A, Mathers C, Zatonski W, La Vecchia C, Ezzati M. National cardiovascular prevention should be based on absolute disease risks, not levels of risk factors. *Eur J Public Health*. 2010;20:103–106. doi: 10.1093/eurpub/ckp067.
29. Prevention of cardiovascular disease: pocket guidelines for assessment and management of cardiovascular risk. World Health Organization. [http://www.who.int/cardiovascular\\_diseases/resources/publications/en/index.html](http://www.who.int/cardiovascular_diseases/resources/publications/en/index.html). Accessed March 28, 2015.
30. Goldstein LB, Bushnell CD, Adams RJ, Appel LJ, Braun LT, Chaturvedi S, et al; American Heart Association Stroke Council; Council on Cardiovascular Nursing; Council on Epidemiology and Prevention; Council for High Blood Pressure Research; Council on Peripheral Vascular Disease, and Interdisciplinary Council on Quality of Care and Outcomes Research. Guidelines for the primary prevention of stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2011;42:517–584. doi: 10.1161/STR.0b013e3181fcb238.
31. Brindle P, Emberson J, Lampe F, Walker M, Whincup P, Fahey T, et al. Predictive accuracy of the Framingham coronary risk score in British men: prospective cohort study. *BMJ*. 2003;327:1267. doi: 10.1136/bmj.327.7426.1267.
32. Dalton AR, Soljak M, Samarasundera E, Millett C, Majeed A. Prevalence of cardiovascular disease risk amongst the population eligible for the NHS Health Check Programme. *Eur J Prev Cardiol*. 2013;20:142–150. doi: 10.1177/1741826711428797.
33. WHO. *Adherence to Long-Term Therapies: Evidence for Action*. Geneva, Switzerland: World Health Organization; 2003.
34. D'Agostino RB, Wolf PA, Belanger AJ, Kannel WB. Stroke risk profile: adjustment for antihypertensive medication. The Framingham Study. *Stroke*. 1994;25:40–43.
35. Hippisley-Cox J, Coupland C, Brindle P. Derivation and validation of QStroke score for predicting risk of ischaemic stroke in primary care and comparison with other risk scores: a prospective open cohort study. *BMJ*. 2013;346:f2573.
36. Mendis S. The contribution of the Framingham Heart Study to the prevention of cardiovascular disease: a global perspective. *Prog Cardiovasc Dis*. 2010;53:10–14. doi: 10.1016/j.pcad.2010.01.001.
37. Cooney MT, Dudina A, D'Agostino R, Graham IM. Cardiovascular risk-estimation systems in primary prevention: do they differ? Do they make a difference? Can we see the future? *Circulation*. 2010;122:300–310. doi: 10.1161/CIRCULATIONAHA.109.852756.
38. Goff DC Jr, Lloyd-Jones DM, Bennett G, Coady S, D'Agostino RB, Gibbons R, et al; American College of Cardiology/American Heart Association Task Force on Practice Guidelines. 2013 ACC/AHA guideline on the assessment of cardiovascular risk: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation*. 2014;129(25 suppl 2):S49–S73. doi: 10.1161/01.cir.0000437741.48606.98.
39. Ng M, Freeman MK, Fleming TD, Robinson M, Dwyer-Lindgren L, Thomson B, et al. Smoking prevalence and cigarette consumption in 187 countries, 1980–2012. *JAMA*. 2014;311:183–192. doi: 10.1001/jama.2013.284692.
40. Kim YS, Park S-S, Bae H-J, Cho AH, Cho Y-J, Han M-K, et al. Stroke awareness decreases prehospital delay after acute ischemic stroke in Korea. *BMC Neurology*. 2011;11:2–8. doi: 10.1186/1471-2377-11-2.
41. Bray JE, Mosley I, Bailey M, Barger B, Bladin C. Stroke public awareness campaigns have increased ambulance dispatches for stroke in Melbourne, Australia. *Stroke*. 2011;42:2154–2157. doi: 10.1161/STROKEAHA.110.612036.
42. Boden-Albala B, Quarles LW. Education strategies for stroke prevention. *Stroke*. 2013;44(6 suppl 1):S48–S51. doi: 10.1161/STROKEAHA.111.000396.
43. Hickey A, O'Hanlon A, McGee H, Donnellan C, Shelley E, Horgan F, et al. Stroke awareness in the general population: knowledge of stroke risk factors and warning signs in older adults. *BMC Geriatr*. 2009;9:35. doi: 10.1186/1471-2318-9-35.
44. Ellis-Hill C, Robison J, Wiles R, McPherson K, Hyndman D, Ashburn A. Going home to get on with life: patients and carers experiences of being discharged from hospital following a stroke. *Disabil Rehabil*. 2009;31:61–72. doi: 10.1080/09638280701775289.
45. Ryan T. Stroke awareness among British ethnic minorities. *Br J Community Nurs*. 2010;15:381–384. doi: 10.12968/bjcn.2010.15.8.71946.
46. Alkadry MG, Tower LE. The effect of rurality and gender on stroke awareness of adults in West Virginia. *J Health Hum Serv Adm*. 2010;33:63–93.
47. Brouillette RM, Foil H, Fontenot S, Corroero A, Allen R, Martin CK, et al. Feasibility, reliability, and validity of a smartphone based application for the assessment of cognitive function in the elderly. *PLoS One*. 2013;8:e65925. doi: 10.1371/journal.pone.0065925.
48. Leung R, Tang C, Haddad S, McGrenere J, Graf P, Ingriany V. How older adults learn to use mobile devices: survey and field investigations. *ACM Trans Access Comput*. 2012;4:11. doi: 10.1145/2399193.2399195.
49. Arab F, Malik Y, Abdulrazak B. Evaluation of PhonAge: an adapted smartphone interface for elderly people. *Lecture Notes Comp Sci*. 2013;8120:547–554.
50. Beratarrechea A, Lee AG, Willner JM, Jahangir E, Ciapponi A, Rubinstein A. The impact of mobile health interventions on chronic disease outcomes in developing countries: a systematic review. *Telemed J E Health*. 2014;20:75–82. doi: 10.1089/tmj.2012.0328.
51. Licskai C, Sands TW, Ferrone M. Development and pilot testing of a mobile health solution for asthma self-management: asthma action plan smartphone application pilot study. *Can Respir J*. 2013;20:301–306.
52. Buller DB, Borland R, Bettinghaus EP, Shane JH, Zimmerman DE. Randomized trial of a smartphone mobile application compared to text messaging to support smoking cessation. *Telemed J E Health*. 2014;20:206–214. doi: 10.1089/tmj.2013.0169.
53. Ly KH, Carlbring P, Andersson G. Behavioral activation-based guided self-help treatment administered through a smartphone application: study protocol for a randomized controlled trial. *Trials*. 2012;13:62. doi: 10.1186/1745-6215-13-62.
54. Carter MC, Burley VJ, Nykjaer C, Cade JE. Adherence to a smartphone application for weight loss compared to website and paper diary: pilot randomized controlled trial. *J Med Internet Res*. 2013;15:e32. doi: 10.2196/jmir.2283.
55. BE HE@LTHY, BE MOBILE. ITU Web site. [http://www.itu.int/en/ITU-D/ICT-Applications/eHEALTH/Pages/Be\\_Healthy.aspx](http://www.itu.int/en/ITU-D/ICT-Applications/eHEALTH/Pages/Be_Healthy.aspx). Accessed March 28, 2015.
56. WHO. *Global Action Plan for the Prevention and Control of Noncommunicable Diseases 2013–2020*. Geneva, Switzerland: World Health Organization; 2012:1–91. [http://apps.who.int/iris/bitstream/10665/94384/1/9789241506236\\_eng.pdf](http://apps.who.int/iris/bitstream/10665/94384/1/9789241506236_eng.pdf). Accessed March 28, 2015.
57. Feigin VL, Krishnamurthi R, Bhattacharjee R, Purohit M, eds. *Stroke Riskometer App*. Auckland, New Zealand: AUTEL of AUT University; 2014.
58. Parmar P, Krishnamurthi R, Ikram MA, Hofman A, Mirza SS, Varakin Y, et al; Stroke Riskometer™ Collaboration Writing Group. The Stroke Riskometer™ App: validation of a data collection tool and stroke risk predictor. *Int J Stroke*. 2015;10:231–244. doi: 10.1111/ijs.12411.
59. Smartphone Users Worldwide Will Total 1.75 Billion in 2014 Mobile users pick up smartphones as they become more affordable, 3G and 4G networks advance. eMarketer Web site. <http://www.emarketer.com/Article/Smartphone-Users-Worldwide-Will-Total-1.75-Billion-2014/1010536>. Accessed March 28, 2015.
60. Bindhim NF, McGeechan K, Trevena L. Assessing the effect of an interactive decision-aid smartphone smoking cessation application (app) on quit rates: a double-blind automated randomised control trial protocol. *BMJ Open*. 2014;4:e005371. <http://dx.doi.org/10.1136/bmjopen-2014-005371>.
61. Kasabov N, Feigin V, Hou ZG, Chen Y, Liang L, Krishnamurthi R, et al. Evolving spiking neural networks for personalised modelling, classification and prediction of spatio-temporal patterns with a case study on stroke. *Neurocomputing*. 2014;134:269–279.
62. Kargman DE, Sacco RL, Boden-Albala B, Paik MC, Hauser WA, Shea S. Validity of telephone interview data for vascular disease risk factors in a racially mixed urban community: the Northern Manhattan Stroke Study. *Neuroepidemiology*. 1999;18:174–184.

KEY WORDS: prevention and control ■ stroke



## SUPPLEMENTAL MATERIAL

**Supplemental Table I.** Summary of Stroke Riskometer App content

App sections and components	
Assess	This is the main assessment section of the app. Users complete questions about age, sex, ethnicity, blood pressure, waist/hip circumference, medical history, medication and lifestyle factors. They are then provided with their 5 and 10 year risk of stroke (absolute risk and relative risk compared to people their age and sex with no risk factors). The Manage component of this section provides users with a list of their risk factors, and in the Pro version they are provided explanations about these factors and how to minimise their impact. Pro users and study participants can also save and track their results in this section.
Research	The Research section contains the information about the RIBURST study. The Participant information sheet and consent form are contained in this section and users need to register/log-in to submit information from here.
Video	Users of the Lite version can see a video about the Stroke Riskometer and how to use it from this section. Pro users also have access to informational videos about what a stroke is, what causes stroke, smoking and diet.
F.A.S.T.	This section informs users about how to easily detect the signs and symptoms of stroke, and what to do if they need to take action.
About	This section gives users more information about how to use the app, more information about the app and acknowledges the team involved with the development of the app.

**Supplemental Table II.** Editors and countries of non-English versions of the Stroke Riskometer™ App

Language	Name and affiliations of Editors of the translated Apps	Country or countries where this language is official or national
Mandarin	Prof. Hua Fu, Fudan University, Shanghai; Prof. Wenzhi Wang, Beijing Neurosurgical Institute, Beijing; People's Republic of China	China, Singapore, Taiwan
Hindi	Prof. Man Mohan Mehndiratta, Janakpuri Super Speciality Hospital, New Delhi; Prof. Jeyaraj Durai Pandian, Christian Medical College, Ludhiana, Punjab; Dr Sanjeev Gupta, Banarsidas Chandiwala Institute of Physiotherapy, Kalkaji, New Delhi; Dr Vasantha Padma, AIIMS New Delhi, India	Fiji, India, Nepal
Spanish	Assoc. Prof. Gustavo Saposnik, University of Toronto, Canada	CARIBBEAN: Cuba, Dominican Republic, Puerto Rico, CENTRAL AFRICA: Equatorial Guinea, CENTRAL AMERICA: Colombia, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama, EUROPE: Spain, NORTH AMERICA: Mexico, SOUTH AMERICA: Argentina, Bolivia, Chile, Ecuador, Paraguay, Peru, Uruguay, Venezuela
Russian	Prof. Michael Piradov, Prof. Yuri Varakin and Dr Michael Kravchenko, Research Center of Neurology, Moscow, Russia	Abkhazia, Belarus, Kazakhstan, Kyrgyzstan, Moldavia, Russia, South Ossetia, Tajikistan, Ukraine

Arabic	Prof. Mohammed Saadah, University of Emirates, United Arab Emirates	Algeria, Bahrain, Chad, Comoros, Djibouti, Egypt, Eritrea, Iraq, Jordan, Kuwait, Lebanon, Libya, Mauritania, Morocco, Oman, Qatar, Saudi Arabia, Somalia, Sudan, Syria, Tunisia, United Arab Emirates, West Bank, Yemen
Bengali	Prof. D.K. Mandal, Founder President of Stroke Foundation of Bengal; Dr. A. Shobhana, Secretary of Stroke Foundation of Bengal and Consultant in Stroke & Critical Care Medicine at the Institute of Neurosciences, Kolkata	Bangladesh and India
Portuguese	Prof. António Freire Gonçalves, Centro Hospitalar e Universitário de Coimbra, Praceta; Prof. Mota Pinto, 3000-075 Coimbra; Prof. Manuel Correia, Hospital de Santo António, Largo Prof. Abel Salazar, Porto; Dr. Teresa Pinho e Melo, Hospital de Santa Maria, Av. Prof. Egas Moniz, 1169-024 Lisboa, Portugal	Angola, Cabo Verde, Guinea-Bissau, Mozambique, Portugal, Timor Lorosae, São Tomé and Príncipe
Brazilian Portuguese	Prof. Norberto Cabral, Joinville Stroke Registry, University of Joinville Region; Dr Sheila C.O. Martins, Brazilian Ministry of Health Advisor, Hospital de Clínicas de Porto Alegre, Hospital Moinhos de Vento; Prof. Luis E. T. A. Furtado, Universidade Federal do Ceará, Sobral, Brazil	Brazil
Malay	Prof Datin Dr Norlinah Mohamed Ibrahim, Dr Ramesh Sahathevan and Dr Wan Nur Nafisah Wan Yahya, UKM Medical Center, Kuala Lumpur, Malaysia	Brunei, Indonesia (Malay), Malaysia (standard Malay), Singapore
French	Prof. Maurice Giroud, University Hospital of Dijon, and University of Burgundy; Dr Yannick Béjot and Prof. Yves Cottin, University of Burgundy, Dijon, France	AFRICA: Benin, Burundi, Burkina Faso, Cameroon, Central African Republic, Chad, Comoros, Democratic Republic of the Congo, Djibouti, Equatorial Guinea, Gabon, Guinea, Ivory Coast, Madagascar, Mali, Niger, Republic of the Congo, Rwanda, Senegal, Seychelles, Togo, CENTRAL AMERICA: Haiti, EUROPE: Aosta Valley, Belgium, France, Guernsey, Luxembourg, Monaco, Switzerland, NORTH AMERICA: Canada, Saint-Barthélemy, Saint-Martin, Saint-Pierre and Miquelon, OCEANIA: French Polynesia, New Caledonia, Vanuatu, Wallis and Futuna
German	Prof. Werner Hacke, Ruprecht Karl University Heidelberg, Germany; Prof. Michael Brainin, Danube University Krems, Vienna, Austria	Austria, Belgium, Germany, Liechtenstein, Luxembourg, Switzerland
Japanese	Chief Doctor Yoshihiro Kokubo, National Cerebral and Cardiovascular Center, Osaka, Japan	Japan

The online version of this article, along with updated information and services, is located on the World Wide Web at:

<http://stroke.ahajournals.org/content/46/6/1740>

Data Supplement (unedited) at:

<http://stroke.ahajournals.org/content/suppl/2015/04/16/STROKEAHA.115.008222.DC1.html>

**Permissions:** Requests for permissions to reproduce figures, tables, or portions of articles originally published in *Stroke* can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the [Permissions and Rights Question and Answer](#) document.

**Reprints:** Information about reprints can be found online at:  
<http://www.lww.com/reprints>

**Subscriptions:** Information about subscribing to *Stroke* is online at:  
<http://stroke.ahajournals.org/subscriptions/>



## New Strategy to Reduce the Global Burden of Stroke

Valery L. Feigin, Rita Krishnamurthi, Rohit Bhattacharjee, Priya Parmar, Alice Theadom, Tasleem Hussein, Mitali Purohit, Patria Hume, Max Abbott, Elaine Rush, Nikola Kasabov, Ineke Crezee, Stanley Frielick, Suzanne Barker-Collo, P. Alan Barber, Bruce Arroll, Richie Poulton, Yogini Ratnasabathiy, Martin Tobias, Norberto Cabral, Sheila C.O. Martins, Luis E.T.A. Furtado, Patrice Lindsay, Gustavo Saposnik, Maurice Giroud, Yannick Béjot, Werner Hacke, Man Mohan Mehndiratta, Jeyaraj Durai Pandian, Sanjeev Gupta, Vasanth Padma, Pipes Kumar Mandal, Yoshihiro Kokubo, Norlinah Mohamed Ibrahim, Ramesh Sahathevan, Hua Fu, Wenzhi Wang, Liping Liu, Zeng-Guang Hou, António Freire Gonçalves, Manuel Correia, Yury Varakin, Michael Kravchenko, Michael Piradov, Mohammed Saadah, Amanda G. Thrift, Dominique Cadilhac, Stephen Davis, Geoffrey Donnan, Alan D. Lopez, Graeme J. Hankey, Annick Maujean, Elizabeth Kendall, Michael Brainin, Foad Abd-Allah, Natan M. Bornstein, Valeria Caso, Juan Manuel Marquez-Romero, Rufus O. Akinyemi, Nasser F. Bin Dhim, Bo Norrving, Shireen Sindi, Miia Kivipelto, Shanthi Mendis, M. Arfan Ikram, Albert Hofman, Saira Saeed Mirza, Peter M. Rothwell, Peter Sandercock, Raad Shakir, Ralph L. Sacco, Antonio Culebras, Gregory A. Roth, Maziar Moradi-Lakeh, Christopher Murray, K.M. Venkat Narayan, George A. Mensah, David Wiebers and Andrew E. Moran  
RIBURST Study Collaboration Writing Group

*Stroke*. 2015;46:1740-1747; originally published online April 16, 2015;  
doi: 10.1161/STROKEAHA.115.008222

*Stroke* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231  
Copyright © 2015 American Heart Association, Inc. All rights reserved.  
Print ISSN: 0039-2499. Online ISSN: 1524-4628

**Permissions:** Requests for permissions to reproduce figures, tables, or portions of articles originally published in *Stroke* can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the [Permissions and Rights Question and Answer](#) document.

**Reprints:** Information about reprints can be found online at:  
<http://www.lww.com/reprints>

**Subscriptions:** Information about subscribing to *Stroke* is online at:  
<http://stroke.ahajournals.org/subscriptions/>