

Usability and feasibility of PreventS-MD webapp for stroke prevention

Journal:	<i>International Journal of Stroke</i>
Manuscript ID	IJS-05-23-10972.R2
Manuscript Type:	Research
Date Submitted by the Author:	09-Jul-2023
Complete List of Authors:	<p>Feigin, Valery; AUT University, National Institute for Stroke & Applied Neurosciences Krishnamurthi, Rita; Auckland University of Technology School of Business, National Institute for Stroke and Applied Neurosciences Medvedev, Oleg; AUT University, National Institute for Stroke & Applied Neurosciences Merino, Alexander ; Auckland University of Technology Rajakrishnan, Bala; AUT University, National Institute for Stroke & Applied Neurosciences Kravchenko, Michael; FSBSI Neurology Research Center Jalili Moghaddam, Shabnam; AUT University, National Institute for Stroke & Applied Neurosciences; Shabnam Jalili Moghaddam Barker-Collins, Suzanne; University of Auckland, Psychology Rathnasabapathy, Yogini; Waitemata District Health Board Skinner, Luke; Waitemata District Health Board Owolabi, Mayowa; University of Ibadan, Medicine Norrving, Bo; Lund University, Department of Clinical Sciences Sachdev, Perminder; University of New South Wales, Centre for Healthy Brain Ageing Arroll, Bruce; University of Auckland, Medicine Brainin, Michael; Danube University, Krems, Thrift, Amanda; Monash University, Epidemiology and Prevention Unit Hankey, Graeme; Sir Charles Gairdner Hospital, Department of Neurology Abdallah, Foad; Cairo University Akinyemi, Rufus; Federal Medical Centre, Azarpazhooh, Mahmoud Reza; Western University, CTS Bhatia, Anjali; AUT University, National Institute for Stroke & Applied Neurosciences Bath, Philip; University of Nottingham, Stroke, Division of Clinical Neuroscience Brayne, Carol; University of Cambridge Budincevic, Hrvoje; Klinicna bolnica Sveti Duh, Department of Neurology; Sveuciliste Josipa Jurja Strossmayera u Osijeku Medicinski Fakultet Osijek, Child, Nicholas; Auckland City Hospital Chwojnicky, Kamil; Medical University of Gdańsk Faculty of Pharmacy Correia, Manuel; University of Porto Davis, Alan; Northland District Health Board, Health of Older People Devlin, Gerry; National Heart Foundation of New Zealand Demarin, Vida; Croatian Academy of Sciences and Arts, Medical Sciences Dhamija, Rajinder; Institute of Human Behaviour and Allied Sciences Ding, Ding; Fudan University Huashan Hospital Institute of Neurology Dokova, Klara; Medical University Prof. Dr. P.Stoyanov Dudley, Makarena; The University of Auckland - City Campus</p>

Dyer, Jessie; AUT University, National Institute for Stroke & Applied Neurosciences
 Edmonds, Misty; Iwi United Engagement Ltd
 Ely, Marcela; St. Anne's University Hospital in Brno
 Farhoudi, Mehdi; Tabriz University of Medical Sciences, Neurosciences
 Feigin, Svetlana; All Life Institute
 Fornolles, Caroline; Luton and Dunstable University Hospital
 Aziz, Aznida Firzah Abdul; Universiti Kebangsaan Malaysia Medical Centre
 Gabriel, Denis; Centro Hospitalar Universitário do Porto EPE
 Gall, Seana; University of Tasmania, Menzies Institute for Medical Research
 Gil, Artyom; WHO European Office for the Prevention and Control of Noncommunicable Diseases, Moscow
 Gnedovckaya, Elena; FSBSI Neurology Research Center
 George, Ann; Auckland University of Technology
 Haršány, Michal; St. Anne's University Hospital in Brno, Departement of Neurology; St. Anne's University Hospital in Brno, International Clinical Research Centre
 Harwood, Matire; The University of Auckland, Te Kupenga Hauora Māori
 Hillis, Argye; Johns Hopkins University School of Medicine, Neurology
 Hou, Zeng-Guang; Institute of Automation, Chinese Academy of Sciences
 Hwang, Kevin; The University of Texas Health Science Center at Houston John P and Katherine G McGovern Medical School
 Ibrahim, Norlinah; Pusat Perubatan Universiti Kebangsaan Malaysia, Medicine
 Ka'ai, Tania; Auckland University of Technology
 Kalra, Nidhi; Parasidas Chandiwala Institute of Physiotherapy
 Katzenellenbogen, Judith; University of Western Australia, Combined Universities Centre for Rural Health; University of Western Australia, School of Population Health
 Law, Zhe Kang; UKM Medical Centre, Department of Medicine; University of Nottingham, Stroke Trials Unit, Division of Clinical Neuroscience
 Kar, Arindam; Middlemore Hospital
 Karaszewski, Bartosz; Medical University of Gdansk, Department of Adult Neurology
 Kazin, Vitalij; Venlo University
 Kivipelto, Miia; Karolinska Institutet, Epidemiology
 Kamenova, Saltanat; Al-Farabi Kazakh National University
 Kondybayeva, Aida; Al-Farabi Kazakh National University
 Lavados, Pablo; Universidad del Desarrollo, Departamento de Neurologia y Psiquiatria
 Lee, Tsong-Hai; Chang Gung Memorial Hospital, Linchu Department of Surgery
 Liu, Liping; Beijing Tiantan Hospital, Neurology;
 Mahawish, Karim; Middlemore Hospital
 Maluchnik, Michał; Ministry of Health of the Republic of Poland
 Martins, Sheila; Federal University of Rio Grande do Sul, Neurology
 Mateen, Farrah; Massachusetts General Hospital, Neurology
 Mavaddat, Nahal; University of Western Australia Faculty of Law
 Mehndiratta, Man Mohan; B.L. Kapur Hospital Centre for Neurosciences
 Mikulik, Robert; St. Anne's University Hospital, Masaryk University, International Clinical Research Center, Neurology
 Oliver, Angela; Waitemata District Health Board
 Ozturk, Serefnur; Selçuk University Faculty of Medicine
 Patel, Nikhil; Luton and Dunstable University Hospital
 Piradov, Michael; FSBSI Neurology Research Center
 Prakash, Binita; Waitemata District Health Board
 Purvis, Tara; Monash University
 Reips, Ulf-Dietrich; University of Konstanz
 Roos, Kev; Iwi United Engagement Ltd

	<p>Rosand, Jonathan; Massachusetts General Hospital, Neurology Sahathevan, Ramesh; UKM Medical Centre, Sekaran, Lakshmanan; Luton and Dunstable University Hospital Shamalov, Nikolay; Pirogov Russian National Research Medical University Silva, Deidre de; The National Neuroscience Institute Singh, Vinod; Waitemata District Health Board Solomon, Alina; Karolinska Institute Srivastava, Padma; All India Institute of Medical Sciences, Neurology Suwanwela, Nijasri; Chulalongkorn University Faculty of Medicine, Division of Neurology, Department of Medicine Taylor, Denise; Auckland University of Technology Truelsen, Thomas; University Hospital of Copenhagen Rigshospitalet, Stroke Center Rigshospitalet; University of Copenhagen Faculty of Health Sciences Venketasubramanian, Narayanaswamy; Raffles Hospital, Raffles Neuroscience Centre Volevach, Katerina; St. Anne's University Hospital Volny, Ondrej; University Hospital Ostrava, Department of Neurology; University of Ostrava, Faculty of Medicine; Masaryk University Institute of Biostatistics and Analyses, Czech National Centre for Evidence-Based Healthcare and Knowledge Translation Wan, Joyce; Waitemata District Health Board Withanapathirana, Katila; Three Kings Accident and Medical Clinic White, Tamara; University of Oslo Wiebers, David; Mayo Clinic, Emeritus Professor of Neurology Wunder, Andrea; Technical University of Erlangen</p>
Keywords:	Stroke, Prevention, Epidemiology, Risk factors, Stroke facilities, Hypertension

SCHOLARONE™
Manuscripts

Usability and feasibility of PreventS-MD webapp for stroke prevention

Prof. Valery L. Feigin, MD, PhD;¹ Prof. Rita Krishnamurthi, PhD;¹ ; Dr. Oleg Medvedev, PhD;² Dr. Alexander Merkin, MD, PhD;¹ Mr. Balakrishnan Nair, MPH;¹ Dr. Michael Kravchenko, MD, PhD;³ Dr. Shabnam Jalili-Moghaddam, PhD;¹ Prof. Suzanne Barker-Collo, PhD;⁴ Dr. Yogini Ratnasabapathy, FRACP, MPH;⁵ Mr. Luke Skinner, BHSc, PGDipBus;⁵ Prof. Mayowa Owolabi, DrM, MD, FAAN, FANA, FRCP, FAMedS, FAAS, FAS;⁶ Prof. Bo Norrving, MD, PhD;⁷ Prof. Perminder S. Sachdev, MD, PhD;⁸ Prof. Bruce Arroll, MD, PhD;⁹ Prof. Michael Brainin, MD, PhD;¹⁰ Prof. Amanda Thrift, PhD;¹¹ Prof. Graeme J. Hankey, MD,¹² on behalf of the Study Team**

¹ National Institute for Stroke and Applied Neurosciences, School of Clinical Sciences, Auckland University of Technology, New Zealand

² School of Psychology, University of Waikato, Hamilton, New Zealand

Research Center of Neurology, Moscow, Russia

⁴ School of Psychology, The University of Auckland, Auckland New Zealand

⁵ Te Whānau Ora Health New Zealand Waitemata

⁶ Center for Genomic and Precision Medicine, College of Medicine, University of Ibadan, Nigeria

⁷ Section of Neurology, Lund University, Skåne University Hospital, Lund, Sweden

⁸ Centre for Healthy Brain Ageing (CHLEA), School of Psychiatry, University of New South Wales (UNSW); Neuropsychiatric Institute, The Prince of Wales Hospital, Sydney, Australia

⁹ Department of General Practice and Primary Health Care, The University of Auckland, New Zealand

¹⁰ Danube University Krems, Austria

¹¹ Department of Medicine, School of Clinical Sciences at Monash Health, Monash University, Melbourne, Victoria, Australia

¹² Medical School, Faculty of Health and Medical Sciences, The University of Western Australia; Perron Institute for Neurological and Translational Science, Perth, Australia

Corresponding author:

Professor Valery L Feigin, MD, PhD, FRSNZ, FRAS, FAAN
National Institute for Stroke and Applied Neurosciences, Auckland University of Technology, 90
Akoranga Dr, Northcote, Auckland 0627, New Zealand. Telephone: +64 9 921 9160; Email:
valery.feigin@aut.ac.nz

* See end of the manuscript for a full list of the Study Team.

ABSTRACT

Background: Most strokes and cardiovascular diseases (CVDs) are potentially preventable if their risk factors are identified and well controlled. Digital platforms, such as the PreventS-MD webapp (PreventS-MD) may aid health care professionals (HCPs) in assessing and managing risk factors and promoting lifestyle changes for their patients.

Methods: This is a mixed methods cross-sectional 2-phase survey using a largely positivist (quantitative and qualitative) framework. During phase 1, a prototype of PreventS-MD was tested internationally by 59 of 69 consenting HCPs of different backgrounds, age, sex, working experience and specialities using hypothetical data. Collected comments/suggestions from the study HCPs in phase 1 were reviewed and implemented. In phase 2, a near-final version of PreventS-MD was developed and tested by 58 of 72 consenting HCPs using both hypothetical and real patient (n=10) data. Qualitative semi-structured interviews with real patients (n=10) were conducted, and 1-month adherence to the preventative recommendations was assessed by self-reporting. The four System Usability Scale (SUS) groups of scores (0-50 unacceptable; 51-68 poor, 68-80.3 good; >80.3 excellent) were used to determine usability of PreventS-MD.

Findings: 99 HCPs from 27 countries (45% from low- to middle-income countries) participated in the study, out of whom 10 HCPs were involved in the development of PreventS before the study, and therefore were not involved in the survey. Of the remaining 89 HCPs 69 consented to the first phase of the survey, out of whom 59 completed the first phase of the survey (response rate 86%) and 58 HCPs completed the second phase of the survey (response rate 84%). The SUS scores supported good usability of the prototype (mean score =80.2; 95% CI [77.0-84.0]) and excellent usability of the final version of PreventS-MD (mean score =84.3; 95%CI [79.1-84.3]) in the field. Scores were not affected by the age, sex, working experience or speciality of the HCPs. One month follow-up of the patients confirmed the high level of satisfaction, acceptability of PreventS-MD and (100%) adherence to the recommendations.

Interpretation: The PreventS-MD webapp has a high level of usability, feasibility and satisfaction by HCPs and individuals at risk of stroke/CVD. Individuals at risk of stroke/CVD demonstrated a high level of confidence and motivation in following and adhering to preventative recommendations generated by PreventS-MD.

Funding: None.

INTRODUCTION

Stroke is the second most common cause of death and the third leading cause of disability in the world.¹ It is a highly preventable disease affecting all ages, ethnicities, and socioeconomic groups.^{1,2} Although the total incidence and mortality rates of stroke and other cardiovascular diseases (CVDs) are declining, the absolute number of people affected by stroke has almost tripled over the last three decades,^{1,3,4} suggesting that currently used primary stroke prevention strategies are not sufficient. There are also issues with secondary stroke prevention. Although 45-80% of recurrent strokes and transient ischaemic attack (TIAs) could be prevented,⁵⁻⁷ no major trends in reducing stroke recurrence rates have been observed over the last two decades in most countries.⁸⁻¹² The lack of adequate post-discharge support/care¹³ and insufficient efficacy of simple advice or a brochure from a GP for secondary stroke prevention¹⁴ have been documented. Appropriately designed motivational digital tools can improve adherence to national primary and secondary stroke prevention guidelines and lead to improved quality of care.¹⁵⁻¹⁷

Based on the validated and internationally endorsed Stroke Riskometer algorithm,¹⁸⁻²¹ digital health guidelines^{16,22,23} and internationally recognised stroke and CVD prevention guidelines,²⁴⁻²⁶ the PreventS-MD webapp^{21,23} is a cognitive behaviour theory-based motivational digital support system for HCPs to assess a patient's risk of stroke/CVD and provide patient tailored primary and secondary prevention management advice.^{23,27} However, the usability of this digital tool has not yet been established.

The objectives of the study were to: (a) evaluate usability and feasibility of PreventS-MD by HCPs and individuals at risk of stroke/CVD (including recurrent stroke); (b) determine patterns of use and engagement by individuals at risk of stroke/CVD with the recommendations generated within the tool; (c) update the PreventS-MD functionality/interface based on feedback received from the study HCPs; and (d) test usability of the modified version of the PreventS (PreventS-MD) webapp that was updated using feedback from the study HCPs and individuals at risk of stroke/CVD.

METHODS

This is a mixed methods (online survey and interviews) cross-sectional 2-phase survey to evaluate the PreventS-MD patient management system for prevention of stroke and CVD using a largely positivist (quantitative and qualitative) framework.²⁸ Semi-structured interviews with priority areas for investigation were used in the qualitative study. The number of patients was determined by the data saturation criterion.²⁹ The study adhered to the observational study guideline (STROBE guidelines),³⁰ and was undertaken in two phases (Figure 1). Details on the development of PreventS-MD and methodology of the study are provided in the appendix (pp. 2-17).

Study participants and procedures

In the first stage of the study, we approached 98 HCPs (stroke physicians, neurologists, general physicians [GPs], nurses, allied health staff, and health researchers in different settings [hospital, outpatient clinics, research facilities]) who wanted to participate in the study aimed at improving primary and secondary stroke prevention and be considered as co-authors of the manuscript resulting from the study. HCPs who were English-speaking, of any age, sex, race/ethnicity, and geographic locality were invited via circulating emails through the networks of the World Stroke Organization (WSO) and the National Institute for Stroke and Applied Neurosciences at Auckland University of Technology. There were no specific selection criteria for the contributors and all HCPs from those networks who expressed their interest to participate in the study were included. Of the 98 HCPs, 16 were involved in the development of the PreventS webapp before the study and, therefore, were not invited to provide informed consent and participate in the survey. Of the remaining 82 HCPs, 69 consented to the first phase of the survey and out of these, 59 completed the first phase of the survey (response rate 86%). Consented HCPs were asked to complete an anonymised online survey with

pre-determined and open-ended questions, including the validated System Usability Scale (SUS)³¹ for determining usability of PreventS-MD. Specifically, HCPs were asked to answer three sets of questions (A, B, and C; Appendix Tables 1-2). In section A, they were asked their opinion about the need for innovative primary stroke prevention. In section B, they were asked about how much they think they might use PreventS-MD with their patients and how they think they would use it, and in section C, they were asked their opinion about different features they would prefer to see in the software.

In the second phase of the study, 69 HCPs who consented to participate in the first phase of the survey were invited to participate in the second phase and 58 (84%) of them completed the second phase of the survey. At this stage of the survey individuals at increased risk of stroke and/or CVD (including people who had experienced stroke or TIA) were invited to participate in the study. They were evaluated at the outpatient clinic for stroke risk and risk factors management by 2 HCPs using PreventS-MD to determine their satisfaction/acceptability with the app and 1-month self-reported adherence to the preventative recommendations. Inclusion criteria were: (a) presence of at least one lifestyle risk factor (e.g., smoking, overweight, sedentary lifestyle, etc.) or metabolic risk factor (e.g., elevated blood pressure, diabetes mellitus, etc.) for stroke; (b) age 20+ years; (c) fluency in English; and (d) informed consent to participate in the study. We enrolled 4 individuals with and 6 individuals without history of stroke or TIA. Individuals with a history of acute coronary syndrome, alcoholism, major psychiatric disorder, malignancy, and/or life expectancy less than 5 years (as judged by the study clinician) were excluded from the study.

Measures

In the first phase of the study, evaluation of PreventS comprised utilisation of the commonly used SUS³¹ and an additional study questionnaire (appendix pp. 3-17). We reviewed the results of the online survey, including recommendations for improving the functionality, interface and usability of the prototype of PreventS-MD called PreventS- webapp. Using the feedback collected we updated PreventS by improving the layout and reporting sections of the webapp and upgraded it to the final version – PreventS-MD which was tested during the second phase of the study. In both phases of the study we tested usability of PreventS and PreventS-MD using hypothetical data. In addition, in phase 2 of the study two physicians in New Zealand tested PreventS-MD by assessing 10 real patients in clinical settings. The HCPs who conducted the assessments and individuals who underwent the assessment were then contacted by a qualitative study researcher for a semi-structured telephone interview about their experience of using PreventS-MD.

Statistical considerations

Data collected from both phases were analysed using quantitative and qualitative methods. Quantitative data were analysed using descriptive analysis methods, including an empirical evaluation of the SUS.³¹ The SUS is composed of 10 statements that are scored on a 5-point scale of strength of agreement. With the validated mean SUS score of 68 (SD 12.5) as the benchmark for usability of digital health apps,³² the overall SUS score was analysed and usability was categorised into 4 validated groups: unacceptable (0-50), poor (51-68), good (69-80.3) and excellent (>80.3).³³ The influence of demographic predictors (age, sex, working experience, specialty of the HCPs) and prior knowledge of the Stroke Riskometer on SUS score was examined using multiple linear regression, and the F-test statistics with the degrees of freedom was reported. Pre-determined sub-group analyses exploring effects of various covariates on the SUS composite score were also conducted. A statistical significance level of $p \leq 0.05$ was considered as significant.

Transcripts from qualitative interviews were transcribed verbatim and, along with the open-ended questions from the surveys/questionnaires, analysed using conventional direct content analysis³⁴ focusing more on a qualitative understanding of the usability of PreventS-MD. De-identified,

illustrative quotes (appendix pp.20-22) were used when reporting these data according to the COREQ reporting guidelines³⁵ (for additional details on statistical analysis see appendix p.5).

Ethical approval

Ethical approvals were obtained for each phase separately, from the Auckland University of Technology Ethics Committee (ref. 21/207) and the Health and Disability Ethics Committee of New Zealand (ref. 2022 EXP 12136) respectively.

RESULTS

Demographic characteristics of the HCPs

The majority of HCPs involved in the study (88.1%; 52/59) were aged 35-64 years, had 23.7 (SD 10.9) years of working experience, with 67.8% (40/59) working in hospitals and 11.9% (7/59) working in outpatient clinics (Table 1). Females comprised 42.4% (25/59) of respondents. Prior to the survey 86.4% (51/59) had used or seen the Stroke Riskometer app. There were no detectable sex differences between those completing phase 1 and phase 2 of the study.

First phase of the study

During the first phase of the study, 83 HCPs from 27 countries (55% [15/27] from high-income countries [HICs] and 45% [12/27] from low- to middle-income countries [LMICs], Figure 2) were approached and initially expressed their interest to participate in the study. Among these, 83.1% (69/83) provided informed consent and 86% (59/69) of those who consented, completed the survey. There were no detectable sex differences between those completing phase 1 and phase 2 of the study (Table 1; $p=0.29$). At the first phase of the study, the PreventS prototype was tested 140 times using hypothetical data from 85 'patients'.

The percentage agreement for individual survey items exceeded 90% for the items in Section A which assessed the needs for innovative primary stroke/CVD prevention strategies, more than 90% agreed to six of the eight items of Section B which assessed the advantages of using PreventS-MD and over 83% agreed to 10 of the 12 items of Section C concerning important features of PreventS-MD for primary stroke/CVD prevention (appendix Table 1A and Table 2). The SUS mean score of 80.2 (95%CI [77.0, 84.0]) for phase 1 indicated that the app was of good acceptability (Table 1).

Second phase of the study

In phase 2, a near-final version of the PreventS-MD webapp was developed and tested by 58 (84%) of consenting HCPs using both hypothetical and real patient ($n=10$) data. The mean SUS usability score was 81.7 (95% CI [79.1, 84.3]), meaning that the webapp had an excellent acceptability (Table 2).

With 10 patients interviewed we achieved enough data for the content analysis, thus further data collection was deemed unnecessary as it would not produce value-added insights. Content analysis of qualitative interviews with 10 patients at risk of stroke and CVD and two of their GPs (general physician, geriatrician) showed high level of understanding and usefulness of PreventS-MD by both patients and HCPs (appendix pp.20-22). At the second phase of the study, the updated PreventS-MD was tested 110 times using hypothetical data of 65 'patients' and data of 10 real patients. The results of testing on hypothetical 'patients' were consistent with results of testing on real patients. The qualitative follow-up interviews with the participants at one-month after a stroke risk assessment and prevention consultation using PreventS-MD indicated a 100% adherence to recommendations, as measured by self-reporting.

Importantly, the SUS scores at phase 1 and phase 2 were not affected by age, sex, working experience, specialty of the HCPs or prior knowledge of the Stroke Riskometer. Specifically, at phase 1, the overall effect of all demographic predictors on the SUS scores was not statistically significant ($F(5, 52)= 1.40$;

$p = 0.24$) with the following estimates for individual predictors: age ($\beta=0.33$; $p=0.11$), sex ($\beta=0.03$; $p=0.64$), working experience ($\beta=0.44$; $p=0.03$), specialty of the HCPs ($\beta=-0.14$; $p=0.34$), or prior knowledge of the Stroke Riskometer ($\beta=-0.13$; $p=0.37$), which was deemed not significant after Bonferroni adjustments. Similarly, at phase 2, there was no significant overall effect of demographic predictors on the SUS scores ($F(5, 49) = 0.79$; $p = 0.56$) with no significant estimates for individual predictors: age ($\beta=-0.08$; $p=0.72$), sex ($\beta=0.04$; $p=0.80$), working experience ($\beta=0.32$; $p=0.14$), specialty of the HCPs ($\beta=0.02$; $p=0.16$), or prior knowledge of the Stroke Riskometer ($\beta=-0.07$; $p=0.61$).

DISCUSSION

This was the first, relatively large study testing usability of PreventS-MD. The study showed the excellent usability of PreventS-MD was not affected by the age, sex, working experience or specialty of the HCPs. There was a strong consensus among HCPs that: (a) stroke prevention can be significantly improved with a validated, easy to use digital stroke management and prevention tool embedded into the existing electronic patient management system to pre-populate as many as possible PreventS-MD variables; (b) PreventS-MD is an easy-to-use, motivational, time- and resource-saving webapp with well-integrated functions they would like to use frequently (almost always) for primary and secondary prevention of stroke and CVD in individuals at increased risk of stroke/CVD; and (c) because recommendations within PreventS-MD are based on the current internationally recognised guidelines for prevention of stroke/CVD and other major NCDs, it will improve patients' understanding of their risk factors and ways they could manage their risk factors, as well as stroke awareness and patient-clinician communication. One month follow-up of the patients confirmed the high level of satisfaction/acceptability of PreventS-MD and self-reported adherence to the recommendations. In line with previous observations,^{14,36-38} our HCP survey identified a clear gap between current evidence-based knowledge in stroke prevention and the awareness and knowledge of the general population, with a lack of motivation of individuals at increased risk of stroke to modify and control their risk factors.

Testing of the webapp among HCPs of different specialties in different settings (hospital, outpatient clinics, research facilities) adds to the generalisability of the findings. Testing the webapp in two phases (hypothetical data and clinical practice with real patients) at two stages of development of the webapp (webapp prototype and final webapp) allowed us to significantly improve and validate usability of the final webapp. An additional strength of the study was the use of a standard tool (SUS) for assessing usability of the webapp, thus allowing comparisons with usability testing of other similar tools. We also tested the system among a relatively large number of HCPs representing both HICs and LMICs across various age, sex, working experience and settings, further adding to the generalisability of the study results. In addition, the PreventS-MD webapp for HCPs used in combination with the cross-culturally validated and free to use Stroke Riskometer app for lay people,^{19,39} as recommended by Huckman and Stem⁴⁰ for sustainability and effectiveness of the apps for chronic conditions, has the potential to be the first integrative and effective mass individual stroke/CVD and other major NCDs preventive strategy.

However, our study has some limitations. Firstly, we selected potential study HCPs from the WSO and Auckland University of Technology networks and tested the webapp using HCPs who mainly worked in hospital settings and were interested in testing a digital webapp for improving primary and secondary stroke prevention. These study HCPs may be more readily amenable to using the webapp than HCPs without such interest. We did not inform the potential study HCPs about specifics of the software to be tested. Apart from 12% of HCPs who work exclusively in outpatient clinics, about 80% of HCPs who indicated working primarily in the hospitals also consulted in outpatient clinics (primary consultations, follow-ups), and 8 of 59 HCPs (13.6%) who were involved in the first phase of testing PreventS did not use or were not aware of the Stroke Riskometer app. Furthermore, there may have been bias arising from the fact that research participants were aware that they would be included as co-authors on this manuscript. However, the online surveys were completely anonymised, thereby

mitigating this potential for bias. This approach also supports the ecological validity of this research and the likelihood of it being implemented in practice, so could also be considered a strength.^{41,42} Moreover, responses from HCPs who were and were not aware of the Stroke Riskometer app did not significantly differ and were consistent across all age, sex, working experience, specialities and settings (hospital and non-hospital). Although questions in the surveys other than the validated SUS questionnaire were subjective evaluations, the high consistency of responses across different HCPs and countries suggests their face validity and reproducibility. Therefore, we believe that possible selection and information biases did not significantly affect our main findings and in practice PreventS-MD may be of particular use to HCPs who are interested in improving primary and secondary stroke prevention. Secondly, we did not prospectively assess long-term (beyond 1 month) engagement of HCPs with the webapp and patients' adherence with the recommendations for primary and secondary prevention that were generated by the HCPs using the webapp. Although the number of clinicians and patients interviewed in the 2nd phase of the study may seem small (10 patients and 2 clinicians), these numbers were sufficient to achieve data saturation as a criterion for discontinuing data collection in qualitative research.⁴⁰ Thirdly, the average number of HCPs per participating country was less than four, with very few in Africa, Eastern Europe, Latin America, Western Europe, and East and Southeast Asia, thus generalisability of our findings to these regions should be interpreted with caution. We also did not assess the real-life impact of the webapp on clinical workload and patient outcomes, or patient-clinician communication and shared decision-making. These issues as well as the assessment of integration of PreventS-MD into electronic patient management systems and a broader health care ecosystem should be determined in future research, and we are seeking funding for a phase 3 trial of PreventS-MD. The WSO estimated that the wide use of this and other digital tools combined with population-wide strategies, task shifting to community health workers and use of the WHO HEARTS approach will cut the global stroke burden by half and dementia burden by 30%.^{20,43}

Conclusions

The PreventS-MD webapp has excellent usability, high level of readiness to use in routine practice on a regular basis, acceptability, and satisfaction by HCPs and individuals at risk of stroke/CVD. This digital tool was shown to reduce prevention-related consultation time for HCPs from an average 20 minutes to 3-5 minutes and improve uptake of evidence-based guidelines for providing effective person-centred recommendations for primary and secondary prevention of stroke and primary prevention of CVD.

In accordance with the WHO recommendations to expand the use of digital technologies and increase health service access and efficacy for NCD prevention,⁴⁴ this validated digital tool can be used by HCPs for prevention of stroke and CVD, and other major NCDs with shared risk factors (e.g., type 2 diabetes mellitus, cancer, dementia, chronic obstructive pulmonary disease, chronic kidney disease, pulmonary embolism / deep vein thromboembolism, pneumonia, and hip fracture).⁴⁵ The wide use of the Stroke Riskometer app by laypeople and the PreventS-MD webapp by HCPs, would foster social inclusion, reinforce the achievements of the Sustainable Development Goals, reduce inequity in preventative services and facilitate bridging the gap in universal health coverage for the poorest billion people in the world.²¹ Although efforts for a global scale-up of PreventS-MD are warranted, further implementation research is needed to determine the effectiveness and long-term adherence to the preventative recommendations.

Acknowledgements

We would like to thank HCPs and patients who participated in this study, the Stroke Foundation of New Zealand for reviewing of and valuable comments on the PreventS-MD webapp, and the Cybersecurity Research Center at Unitec Institute of Technology for preliminary testing of the PreventS-MD webapp for security.

Source of funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Disclosure statement

VLF, RK, BN, SJM, AM, MK declare that PreventS-MD webapp and the free Stroke Riskometer app are owned and copyrighted by Auckland University of Technology (AUT) Ventures Ltd, New Zealand. Other co-authors reported no conflict of interest.

Study Team (in alphabetical order)

Foad Abd-Allah;¹ Rufus Akinyemi;² Reza Azarpazhooh;³ Anjali Bhatia;⁴ Philip M. Bath;⁵ Carol Brayne;⁶ Hrvoje Padincevic;⁷ Nicholas Child;⁸ Kamil Chwojncki;⁹ Manuel Correia;¹⁰ Alan Davis;¹¹ Gerry Devlin;¹² Veda Demerin;¹³ Rajinder K. Dhamija;¹⁴ Ding Ding;¹⁵ Klara Dokova;¹⁶ Makarena Dudley;¹⁷ Jesse Dyer;⁴ Misty Edmonds;¹⁸ Marcela Ely;¹⁹ Mehdi Farhoudi;²⁰ Svetlana Feigin;²¹ Caroline Fornolles;²² Aznida Firzah Abdul Aziz;²³ Denis Gabriel;²⁴ Seana Gall;²⁵ Artyom Gil;²⁶ Elena Gnedovskaya;²⁷ Ann George;⁴ Michal Haršány;¹⁹ Matire Harwood;²⁸ Argye Hillis;²⁹ Zeng-Guang Hou;³⁰ Kevin Hwang;³¹ Norliyah Ibrahim;²³ Tania Ka'ai;³² Nidhi Kalra;³³ Judith Katzenellenbogen;³⁴ Law Zhe Kang;²³ Arindam Kar;³⁵ Ryszard Karaszewski;³⁶ Vitalij Kazin;³⁷ Miia Kivipelto;³⁸ Saltanat Kamenova;³⁹ Aida Kondybaeva;⁴⁰ Pablo Lavados;⁴⁰ Tsong-Hai Lee;⁴¹ Liping Liu;⁴² Karim Mahawish;³⁵ Michal Maluchnik;⁴³ Sheila Martins;⁴⁴ Farrah Mateen;⁴⁵ Nahal Mavaddat;³⁴ Man Mohan Mehndiratta;⁴⁶ Robert Mikulil;¹⁹ Angela Oliver;⁸ Serefnur Öztürk;⁴⁷ Nikhil Patel;²² Michael Piradov;²⁷ Binita Prakash;⁸ Tama Purvis;⁴⁸ Ulf-Dietrich Reips;⁴⁹ Kev Roos;¹⁸ Jonathan Rosand;⁵⁰ Ramesh Sahathevan;⁵¹ Lakshmanan Sekaran;²⁴ Nikolay Shamalov;⁵² Deidre Anne De Silva;⁵³ Vinod Singh;⁸ Alina Solomon;³⁸ Padma Srivastava;⁵⁴ Anisur C. Suwanwela;⁵⁵ Denise Taylor;⁵⁶ Thomas Truelsen;⁵⁷ Narayanaswamy Venkatesubramanian;⁵⁸ Ekaterina Volevach;¹⁹ Ondřej Volný;⁵⁹ Joyce Wan;⁸ Katila Withanapathirana;⁶⁰ Tama Wlita;⁶¹ David Wiebers;⁶² Andrea S. Winkler;⁶³ Tissa Wijeratne;⁶⁴ Teddy Wu;⁶⁵ Wan Asyraf Wan Zaidi.²⁷

1. Department of Neurology, Kasr Al Ainy School of Medicine, Cairo University, Cairo, Egypt.
2. Neuroscience and Ageing Research Unit, Institute for Advanced Medical Research and Training, College of Medicine, University of Ibadan, Ibadan, Nigeria.
3. Department of Clinical Neurological Sciences and Epidemiology, University of Western Ontario, London, ON, Canada.
4. National Institute for Stroke and Applied Neurosciences, Auckland University of Technology, Auckland, New Zealand.
5. Stroke Trials Unit, Mental Health & Clinical Neuroscience, University of Nottingham, Nottingham, UK.
6. Institute of Public Health, University of Cambridge, UK
7. Sveti Duh University Hospital, Department of Neurology, Zagreb, Croatia; J.J. Štrossmayer University of Osijek, Faculty of Medicine, Department of Neurology and Neurosurgery, Osijek, Croatia.
8. Te Whatu Ora - Health New Zealand, Waitematā, Auckland, New Zealand.
9. Division of Anaesthesiology & Intensive Care, Faculty of Medicine, Medical University of Gdańsk, Poland.
10. Department of Neurology, Centro Hospitalar Universitário do Porto, Instituto de Ciências Biomédicas Abel Salazar, University of Porto, Portugal.
11. Te Whatu Ora - Health New Zealand, Te Tai Tokerau (Northland), Whangārei, New Zealand.

12. Te Whatu Ora - Health New Zealand, Tairāwhiti, New Zealand; New Zealand Heart Foundation, New Zealand.
13. Department of Medical Sciences of the Croatian Academy of Sciences and Arts, Zagreb, Croatia.
14. Institute of Human Behavior and Allied Sciences New Delhi, India.
15. Institute of Neurology, Fudan University Huashan Hospital, China.
16. Faculty of Public Health, Medical University "Prof. Dr. P.Stoyanov" Varna, Bulgaria.
17. School of Psychology, The University of Auckland, Auckland, New Zealand.
18. Iwi United Engagement Ltd, Auckland, New Zealand.
19. International Clinical Research Centre, St. Anne's University Hospital in Brno, Brno, Czech Republic.
20. Neuroscience Research Center, Tabriz University of Medical Sciences, Tabriz, Iran.
21. All Life Institute, Washington D.C., USA
22. Luton and Dunstable University Hospital, Bedfordshire, UK.
23. Universiti Kebangsaan Malaysia Medical Centre, Kuala Lumpur, Malaysia.
24. Department of Neurology, Hospital de Santo António, Centro Hospitalar Universitário do Porto, Porto, Portugal.
25. Menzies Institute for Medical Research, University of Tasmania, Tasmania, Australia.
26. Division of Country Health Programmes, WHO European Office for the Prevention and Control of Noncommunicable Diseases, Moscow, Russia; WHO country office, Astana, Kazakhstan.
27. Research Center of Neurology, Moscow, Russia.
28. Faculty of Medical and Health Sciences, University of Auckland, New Zealand.
29. Johns Hopkins University, Baltimore, MD, USA.
30. State Key Lab of Management and Control for Complex Systems, Institute of Automation, Chinese Academy of Sciences, Beijing, China.
31. McGovern Medical School at UTHealth Houston, Houston, TX, USA
32. Te Ipukarea Research Institute, Faculty of Design and Creative Technologies, Auckland University of Technology, Auckland, New Zealand.
33. Banarsidas Chandiwala Institute of Physiotherapy GGSIP University, New Delhi, India.
34. University of Western Australia, Perth, Australia.
35. Te Whatu Ora – Health New Zealand, Counties Manukau, Auckland, New Zealand.
36. Department of Adult Neurology, Faculty of Medicine, Medical University of Gdansk, Gdansk, Poland; Brain Diseases Center, Medical University of Gdansk, Poland.
37. CPPN, Venlo University, the Netherlands.
38. Karolinska Institutet, Sweden.
39. Higher School of Medicine, al-Farabi Kazakh National University, Almaty, Kazakhstan.
40. Department of Neurology & Psychiatry, Research & Clinical Trials Unit, Clínica Alemana, Universidad del Desarrollo, Santiago, Chile

41. Stroke Center and Department of Neurology, Linkou Chang Gung Memorial Hospital, Taoyuan, Taiwan.
42. Department of Neurology, Beijing Tiantan Hospital, Capital Medical University, Beijing, China.
43. Ministry of Health of the Republic of Poland, Warsaw, Poland.
44. Universidade Federal do Rio Grande do Sul, Hospital de Clínicas de Porto Alegre; Hospital Moinhos de Vento, Brazil.
45. Department of Neurology, Massachusetts General Hospital, Boston, MA, USA.
46. P. L. Kapur Hospital Centre for Neurosciences, New Delhi, India.
47. Sıgırcı University Faculty of Medicine, Department of Neurology, Konya, Turkey.
48. Stroke and Ageing Research Group (STAR) in the School of Clinical Sciences at Monash Health, Monash University, Melbourne, Australia.
49. Research Methods, Assessment & Science, Department of Psychology, University of Konstanz, Konstanz, Germany.
50. Henry and Allison McCance Center for Brain Health, Massachusetts General Hospital; Harvard Medical School; Broad Institute, MA, USA.
51. Ballarat Health Services, Ballarat, Australia.
52. Federal Center of Brain Research and Neurotechnologies of the Federal Medical Biological Agency, Moscow, Russian Federation.
53. Department of Neurology, The National Neuroscience Institute, Singapore
54. Department of Neurology, Neurosciences Center, AIIMS, New Delhi, India.
55. Faculty of Medicine, Chulalongkorn University, Chulalongkorn Comprehensive Stroke Center, King Chulalongkorn Memorial Hospital, Bangkok, Thailand.
56. Health and Rehabilitation Research Institute, Auckland University of Technology, Auckland, New Zealand.
57. Department of Neurology, University of Copenhagen, Rigshospitalet, Copenhagen, Denmark.
58. Raffles Neuroscience Centre, Raffles Hospital, Singapore, Singapore.
59. University Hospital Ostrava, Ostrava, Czech Republic.
60. Three Kings Accident and Medical Clinic, Auckland, New Zealand.
61. Department of Neurology, Center for Global Health, Technical University of Munich, Germany; Centre for Global Health, Institute of Health and Society, University of Oslo, Norway.
62. Departments of Neurology and Health Sciences Research, Divisions of Cerebrovascular Diseases and Epidemiology, Mayo Clinic and Mayo Foundation, Rochester, MN, USA.
63. Department of Neurology, University of Erlangen, Erlangen and Nuremberg, Germany; Department of Neurology, Centre for Global Health, Technical University of Erlangen, Germany
64. Department of Neurology, Stroke Services, Department of Medicine, Sunshine Hospital, Western Health, Melbourne Medical School, St Albans, Victoria, Australia.
65. Department of Neurology, Christchurch Hospital, Christchurch, New Zealand.

References

1. Feigin VL, Stark BA, Johnson CO, et al. Global, regional, and national burden of stroke and its risk factors, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet Neurology*. 2021;20:795-820 doi.org/10.1016/S1474-4422(21)00252-00250. doi: doi.org/10.1016/S1474-4422(21)00252-0
2. O'Donnell MJ, Chin SL, Rangarajan S, et al. Global and regional effects of potentially modifiable risk factors associated with acute stroke in 32 countries (INTERSTROKE): a case-control study. *Lancet*. 2016;388:761-775. doi: 10.1016/s0140-6736(16)30506-2
3. Bennett DA, Krishnamurthi RV, Barker-Collo S, et al. The global burden of ischemic stroke: findings of the GBD 2010 study. *Glob Heart*. 2014;9:107-112. doi: 10.1016/j.gheart.2014.01.001
4. Roth GA, Johnson C, Abajobir A, et al. Global, Regional, and National Burden of Cardiovascular Diseases for 10 Causes, 1990 to 2015. *Journal of the American College of Cardiology*. 2017;70:1-25. doi: 10.1016/j.jacc.2017.04.052
5. Hackman DG, Spence JD. Combining multiple approaches for the secondary prevention of vascular events after stroke: a quantitative modeling study. *Stroke*. 2007;38:1881-1885. doi: 10.1161/strokeaha.106.475525
6. Rothwell PM, Giles MF, Chandratheva A, et al. Effect of urgent treatment of transient ischaemic attack and minor stroke on early recurrent stroke (EXPRESS study): a prospective population-based sequential comparison. *Lancet*. 2007;370:1432-1442. doi: 10.1016/s0140-6736(07)61448-2
7. Richards A, Md P, Jackson N, et al. Derivation and Application of a Tool to Estimate Benefits From Multiple Therapies That Reduce Recurrent Stroke Risk. *Stroke*. 2020;51:1563-1569. doi: 10.1161/STROKEAHA.119.027169
8. Flach C, Muruet W, Wolfe CDA, et al. Risk and Secondary Prevention of Stroke Recurrence: A Population-Based Cohort Study. *Stroke*. 2020;51:2435-2444. doi: 10.1161/strokeaha.120.028992
9. Kolmos M, Christoffersen L, Kruuse C. Recurrent Ischemic Stroke - A Systematic Review and Meta-Analysis. *Journal of Stroke and Cerebrovascular Diseases*. 2021;30. doi: 10.1016/j.jstrokecerebrovasdis.2021.105935
10. Rucker V, Heuschmann PU, O'Flaherty M, et al. Twenty-Year Trends in Long-Term Case-Fatality and Recurrence Rates After Ischemic Stroke Stratified by Etiology. *Stroke*. 2020;51:2778-2785. doi: doi:10.1161/STROKEAHA.120.029572
11. Zhao W, Wu J, Liu J, et al. Trends in the incidence of recurrent stroke at 5 years after the first-ever stroke in rural China: a population-based stroke surveillance from 1992 to 2017. *Aging (Albany NY)*. 2019;11:1686-1694. doi: 10.18632/aging.101862
12. Chaudhary D, Khan A, Shahjouei S, et al. Trends in ischemic stroke outcomes in a rural population in the United States. *Journal of the Neurological Sciences*. 2021;422:117539. doi: <https://doi.org/10.1016/j.jns.2021.117339>
13. Harwood MLN, Ranta A, Thompson SG, et al. Barriers to optimal stroke service care and solutions: a qualitative study engaging people with stroke and their whānau. *N Z Med J*. 2022;135:81-93.
14. Kleindorfer DO, Towfighi A, Chaturvedi S, et al. 2021 Guideline for the prevention of stroke in patients with stroke and transient ischemic attack; A guideline from the American Heart Association/American Stroke Association. *Stroke*. 2021:E364-E467. doi: 10.1161/STR.0000000000000375
15. Mehl G, Tunçalp Ö, Ratanaprayul N, et al. WHO SMART guidelines: optimising country-level use of guideline recommendations in the digital age. *The Lancet Digital Health*. 2021;3:e213-e216. doi: 10.1016/S2589-7500(21)00038-8

16. WHO Guideline: recommendations on digital interventions for health system strengthening. 2019 <https://www.who.int/publications-detail-redirect/9789241550505> Accessed 1 November 2021.
17. Murphy ME, Fahey T, Smith SM. Computer-based clinical decision support for general practitioners. *Fam Pract*. 2014;31:497-498. doi: 10.1093/fampra/cmu045
18. Parmar P, Krishnamurthi R, Ikram MA, et al. The Stroke Riskometer(TM) App: validation of a data collection tool and stroke risk predictor. *International Journal of Stroke*. 2015;10:231-244. doi: 10.1111/ijss.12411
19. Medvedev O, Truong Q, Merkin A, et al. Cross-cultural validation of the Stroke Riskometer using generalizability theory. *Scientific Reports Nature Portfolio*. 2021;11:19064 doi.org/10.1038/s41598-19021-98591-19068. doi: 10.1038/s41598-021-98591-8
20. Brinin M, Feigin VL, Norrving B, et al. Global prevention of stroke and dementia: the WSO Declaration. *The Lancet Neurology*. 2020;19:487-488. doi: 10.1016/S1474-4422(20)30141-1
21. Feigin VL, Krishnamurthi R, Merkin A, et al. Digital solutions for primary stroke and cardiovascular disease prevention: a mass individual and public health approach. *The Lancet Regional Health - Western Pacific*. 2022;100511:<https://doi.org/10.1016/j.lanwpc.2022.100511>.
22. Labrique A, Agarwal S, Tamrat T, et al. WHO Digital Health Guidelines: a milestone for global health. *npj Digital Medicine*. 2020;3:120. doi: 10.1038/s41746-020-00330-2
23. Feigin VL, Owolabi MO, Hankey GJ, et al. Digital health in primordial and primary stroke prevention: a systematic review. *Stroke*. 2022;53:1008–1019.
24. Visseren FLJ, Mach F, Smulders MM, et al. 2021 ESC Guidelines on cardiovascular disease prevention in clinical practice : Developed by the Task Force for cardiovascular disease prevention in clinical practice with representatives of the European Society of Cardiology and 12 medical societies With the special contribution of the European Association of Preventive Cardiology (EAPC). *European Heart Journal*. 2021;42:3227-3337. doi: 10.1093/eurheartj/ehab484
25. Arnett DK, Blumenthal RS, Albert MA, et al. 2019 ACC/AHA Guideline on the Primary Prevention of Cardiovascular Disease: Executive Summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Circulation*. 2019;140:e563-e595. doi: 10.1161/CIR.0000000000000677
26. Meschia JF, Bushnell C, Boden-Albala B, et al. Guidelines for the primary prevention of stroke: A statement for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2014;45:3754-3832. doi: 10.1161/STR.0000000000000046
27. Owolabi MO, Thrift AG, Mahal A, et al. Primary stroke prevention worldwide: translating evidence into action. *The Lancet Public Health*. 2021:[https://doi.org/10.1016/S2468-2667\(21\)00230-9](https://doi.org/10.1016/S2468-2667(21)00230-9). doi: 10.1016/S2468-2667(21)00230-9
28. Carpiano RM, Daley DM. A guide and glossary on post-positivist theory building for population health. *Journal of epidemiology and community health*. 2006;60:561-570. doi: 10.1136/jech.2004.031534
29. Hennink M, Kaiser BN. Sample sizes for saturation in qualitative research: A systematic review of empirical tests. *Social Science & Medicine*. 2022;292:114523. doi: <https://doi.org/10.1016/j.socscimed.2021.114523>
30. von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)statement: guidelines for reporting observational studies. *Journal of Clinical Epidemiology*. 2008;61:344-349.
31. Broole J. SUS: A 'Quick and Dirty' Usability Scale <https://doi.org/10.1201/9781498710411>. In: Jordan PW, Thomas B, McClelland L, Weerdmeester B, eds. *Usability Evaluation in Industry, 1st Edition*. London: CRC Press; 2014:1-6.

32. Hyzy M, Bond R, Mulvenna M, et al. System Usability Scale Benchmarking for Digital Health Apps: Meta-analysis. *JMIR mHealth and uHealth*. 2022;10. doi: 10.2196/37290
33. UIUX Trend. Measuring and Interpreting System Usability Scale (SUS). <https://uiuxtrend.com/measuring-system-usability-scale-sus/> Accessed 25 February 2023.
34. Hsieh HF, Shannon SE. Three approaches to qualitative content analysis. *Qual Health Res*. 2005;15:1277-1288. doi: 10.1177/1049732305276687
35. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care*. 2007;19:349-357. doi: 10.1093/intqhc/mzm042
36. Pu C, Guo JY, Yu Hua Y, et al. Comparison of knowledge on stroke for stroke patients and the general population in Burkina Faso: a cross-sectional study. *AIMS Public Health*. 2020;7:723-735. doi: 10.3934/publichealth.2020056
37. Krishnamurthi RV, Barker-Collo S, Barber PA, et al. Community Knowledge and Awareness of Stroke in New Zealand. *Journal of Stroke and Cerebrovascular Diseases*. 2020;29:104589. doi: <https://doi.org/10.1016/j.jstrokecerebrovasdis.2019.104589>
38. Jones GP, Jenkinson AJ, Leathley MJ, et al. Stroke knowledge and awareness: an integrative review of the evidence. *Age and Ageing*. 2009;39:11-22. doi: 10.1093/ageing/afp196
39. Owolabi MO, Thrift AG, Mahal A, et al. Primary stroke prevention worldwide: translating evidence into action. *Lancet Public Health*. 2022;7:e74-e85. doi: 10.1016/S2468-2667(21)00230-9
40. Huckman RS, Stern AD. Why Apps for Managing Chronic Disease Haven't Been Widely Used, and How to Fix It. *Harvard Business Review Technology and Analytics*. 2018; <https://hbr.org/2018/04/why-apps-for-managing-chronic-disease-havent-been-widely-used-and-how-to-fix-it> Accessed 19 December 2022.
41. Cobey KD, Monfaredi Z, Poole E, et al. Editors-in-chief perceptions of patients as (co) authors on publications and the acceptability of LMJE authorship criteria: a cross-sectional survey. *Research Involvement and Engagement*. 2021;7:39. doi: 10.1186/s40900-021-00290-1
42. Andrade C. Internal, External, and Ecological Validity in Research Design, Conduct, and Evaluation. *Indian J Psychol Med*. 2018;40:498-499. doi: 10.4103/ijpsym.ijpsym_334_18
43. Brainin M, Feigin V, Martins S, et al. Cut stroke in half: Polypill for primary prevention in stroke. *International Journal of Stroke*. 2018;13:633-647. doi: 10.1177/1747493018761190
44. NCD Alliance. New submission - WHO Global Action Plan for the Prevention and Control of Noncommunicable Diseases (NCDs) 2013–2030 - Appendix 3. <https://ncdalliance.org/resources/new-submission-who-global-action-plan-for-the-prevention-and-control-of-noncommunicable-diseases-ncds-2013-2030-932030-appendix-3> Accessed 21 October 2022.
45. Ogunmoroti O, Allen NB, Cushman M, et al. Association Between Life's Simple 7 and Noncardiovascular Disease: The Multi-Ethnic Study of Atherosclerosis. *Journal of the American Heart Association*. 2016;5:e003954. doi: doi:10.1161/JAHA.116.003954

Figure legends

Figure 1. Study flowchart

Figure 2. World map showing 27 countries from which experts participated in the survey

Author Peer Review Accepted Manuscript

Table 1. Demographic characteristics of HCPs participating in the Phase 1 ($n=59$) and Phase 2 ($n=58$) surveys

Demographics	Phase 1 ($n=59$) n (%)	Phase 2 ($n=58$) n (%)	χ^2	Total
Sex				
Male	34 (57.6)	34 (58.6)	$P=0.29$	68
Female	25 (42.4)	24 (41.4)		49
Age in years				
25-34	4 (6.8)	5 (8.6)	$P=0.35$	9
35-44	18 (30.5)	14 (24.1)		32
45-54	18 (30.5)	13 (22.4)		31
55-64	16 (27.1)	17 (29.3)		33
65 and over	3 (5.1)	9 (15.5)		12
Place of clinical practice				
General	3 (5.1)	4 (7.0)	$P=0.96$	7
Hospital	40 (67.8)	38 (66.7)		78
Community health	4 (6.8)	4 (7.0)		8
Other	12 (20.3)	11 (19.3)		23

Note. χ^2 =Chi square test for independence.

Table 2. Evaluating PreventS-MD using System Usability Scale³¹ (SUS)

Survey questions*	Strongly disagree		Disagree		Neutral		Agree		Strongly agree	
	Phase 1 (n=59)	Phase 2 (n=58)	Phase 1 (n=59)	Phase 2 (n=58)	Phase 1 (n=59)	Phase 2 (n=58)	Phase 1 (n=59)	Phase 2 (n=58)	Phase 1 (n=59)	Phase 2 (n=58)
I think that I would like to use this PreventS-MD system frequently (n, %)	0(0%)	0 (0%)	0(0%)	0 (0%)	7(12.3%)	6 (10.3%)	31(54.4%)	35 (60.3%)	19(33.3%)	17 (29.3%)
I found the PreventS-MD system unnecessarily complex (n, %)	18(31.6%)	19 (33.3%)	30(52.6%)	26 (45.6%)	7(12.3%)	6 (10.5%)	1(1.8%)	4 (7.0%)	1(1.8%)	2 (3.5%)
I thought the PreventS-MD system was easy to use (n, %)	0(0%)	0 (0%)	1(1.7%)	2 (3.4%)	3(5.2%)	2 (3.4%)	27(46.6%)	35 (60.3%)	27(46.6%)	19 (32.8%)
I am satisfied with the level of time/resources consumed in performing those tasks	22(37.9%)	33 (56.9%)	2(5.7%)	20 (34.5%)	4(6.9%)	2 (3.4%)	0(0%)	3 (5.2%)	0(0%)	0 (0%)
I found the various functions in this PreventS-MD system were well integrated (n, %)	0(0%)	0 (0%)	0(0%)	0 (0%)	4(6.9%)	1 (1.7%)	36(62.1%)	40 (69.0%)	18(31.0%)	17 (29.3%)
I thought there was too much inconsistency in this PreventS-MD system (n, %)	23(39.7%)	21 (36.2%)	28(48.3%)	3 (6.0%)	5(8.6%)	2 (3.4%)	1(1.7%)	0 (0%)	1(1.7%)	0 (0%)
I would imagine that most people would learn to use this PreventS-MD system very quickly (n, %)	0(0%)	0 (0%)	0(0%)	1 (1.7%)	3(5.2%)	1 (1.7%)	31(53.4%)	38 (65.5%)	24(41.4%)	18 (31.0%)
I found the PreventS-MD system very cumbersome to use (n, %)	24(42.1%)	26 (44.8%)	26(45.6%)	30 (51.7%)	5(8.8%)	1 (1.7%)	1(1.8%)	1 (1.7%)	1(1.8%)	0 (0%)
I felt very confident using the PreventS-MD system (n, %)	0(0%)	0 (0%)	0(0%)	0 (0%)	11(19.0%)	3 (5.2%)	31(53.4%)	36 (62.1%)	16(27.6%)	19 (32.8%)
I needed to learn a lot of things before I could get going with this PreventS-MD system (n, %)	18(31.0%)	26 (44.8%)	26(44.8%)	23 (39.7%)	7(12.1%)	7 (12.1%)	5(3.6%)	2 (3.4%)	2(3.4%)	0 (0%)

Total SUS mean score (95% CI) for Phase 1 = 80.2 (77.0-84.0), for Phase 2=81.7 (79.1-84.3). *Total number of HCPs who participated in the first and second surveys (59 and 58, respectively) may not sum up for some of the answers, because not all HCPs who participated in the first and second survey answered each of the questions

Figure 1. Study flowchart

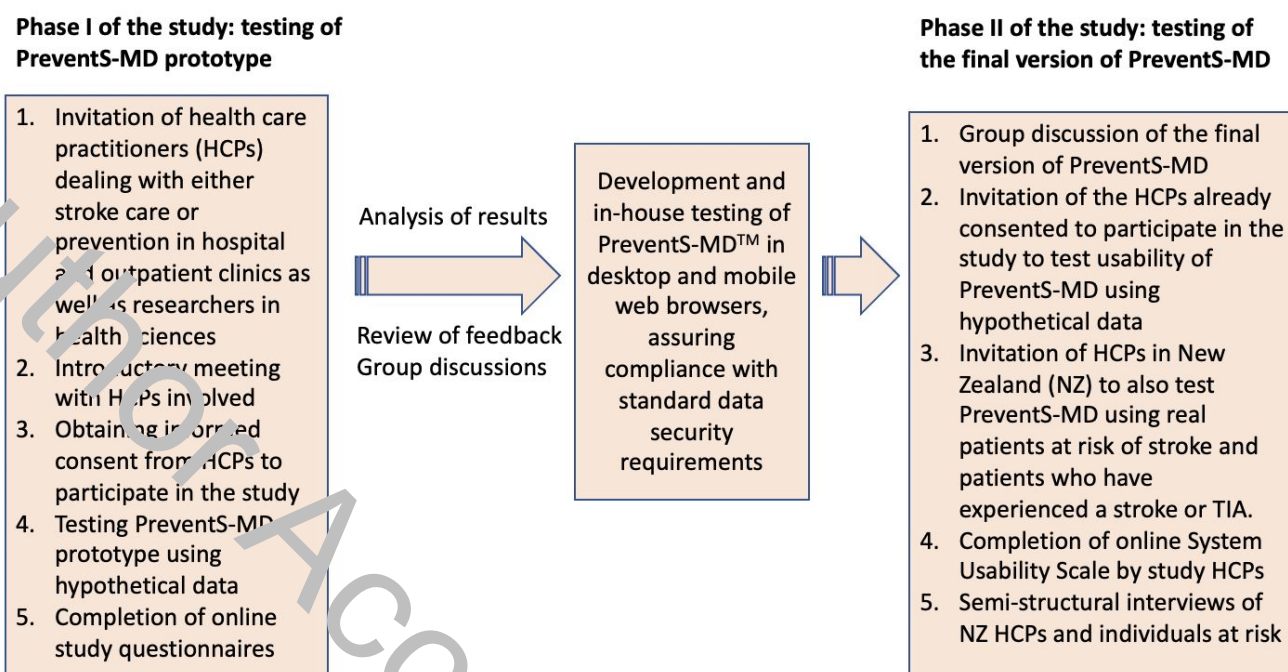
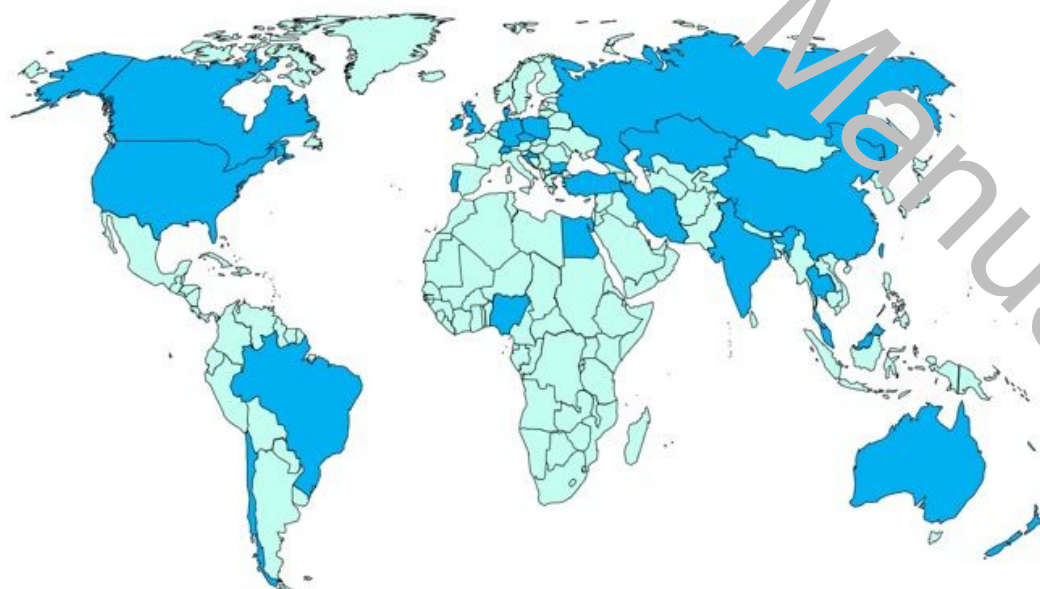


Figure 2. World map showing 27 countries from which experts participated in the survey



List of countries in the study (in alphabetical order): Australia, Brazil, Bulgaria, Canada, Chile, China, Croatia, Czech Republic, Denmark, Egypt, Germany, India, Iran, Kazakhstan, Malaysia, New Zealand, Nigeria, Poland, Portugal, Russia, Singapore, Switzerland, Taiwan, Thailand, Turkey, United Kingdom, United States of America