Usability and feasibility of PreventS-MD webapp for stroke prevention

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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=81.7; 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.

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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/care[13] and insufficient efficacy of simple advice or a brochure from a GP for secondary stroke prevention[14] 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 geographical 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 SUS[31] 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 analysis[34] 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 guidelines[35] (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 HCPs (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 (β=0.33; p=0.11), sex (β=0.03; p=0.64), working experience(β=0.44; p=0.03) , specialty of the HCPs (β=-0.14; p=0.34), or prior knowledge of the Stroke Riskometer (β=-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 (β=-0.08; p=0.72), sex (β=0.04; p=0.80), working experience(β=0.32; p=0.14), specialty of the HCPs (β=0.02; p=0.16), or prior knowledge of the Stroke Riskometer (β=-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 not affected by the age, sex, working experience or speciality 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 specialities 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,[19-21,39] as recommended by Huckman and Stem[40] 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 consulation 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 inequaty 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.

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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.

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Figure legends

Figure 1. Study flowchart
Figure 2. World map showing 27 countries from which experts participated in the survey

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 (%)**	x^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. x^2 =Chi square test for independence

Table 2. Evaluating PreventS-MD using System Usability Scale[31] (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%)	32(55.2%)	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%)	35 (60.3%)	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(8.6%)	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

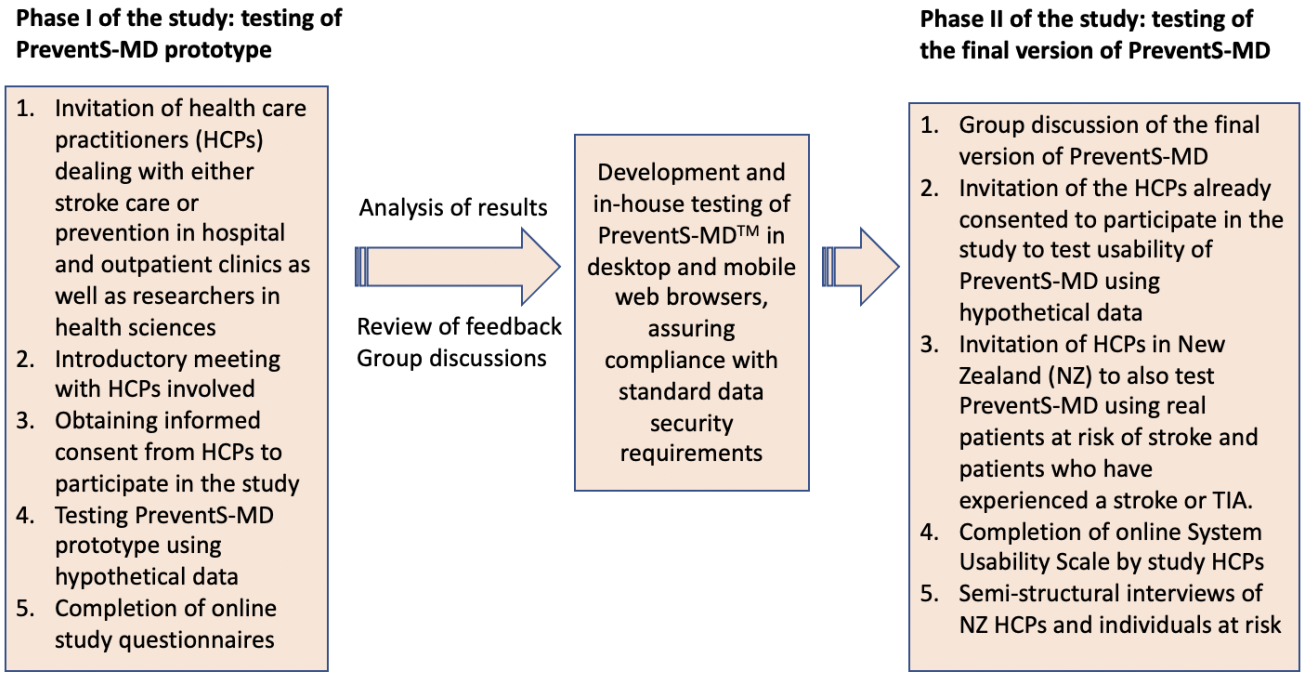
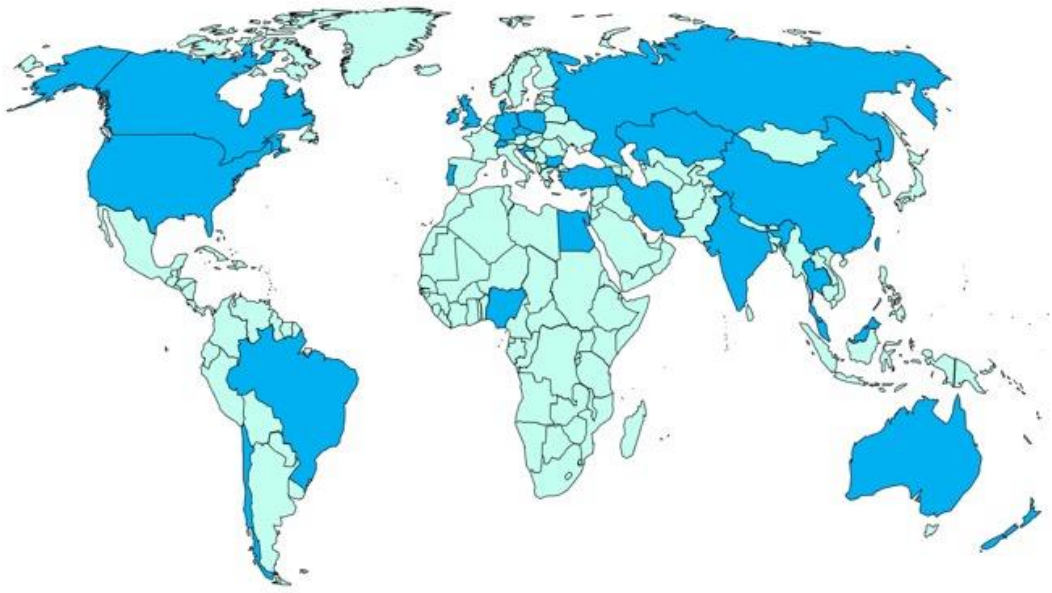


Figure 2. World map showing 27 countries from which experts participated in the survey



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