Clinical Neurology and Neurosurgery 218 (2022) 107297

Contents lists available at ScienceDirect

Clinical Neurology and Neurosurgery

journal homepage: www.elsevier.com/locate/clineuro

Medical attention seeking by suspected stroke patients: Emergency medical services or general practitioner?

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ARTICLE INFO

Keywords:
Stroke
Emergency medical services
Attention seeking

ABSTRACT

Objective: Awareness campaigns advise the public to call emergency medical services (EMS) directly in case of suspected stroke. We aimed to explore patient and notification characteristics that influence direct EMS notification, the time to alert, and the time to treatment.

Methods: We performed a secondary analysis with data from the PRESTO study, a multi-center prospective observational cohort study that included patients with suspected stroke. We used multivariable binary logistic regression analyses to assess the association with direct EMS notification and multivariable linear regression analyses to assess the association with the onset-to-alert time, onset-to-needle time and onset-to-groin time.

Results: Of 436 included patients, 208 patients (48%) contacted EMS directly. FAST scores (aOR 1.45 for every point increase, 95%CI: 1.14–1.86), alert outside office hours (aOR 1.64 [1.05–2.55]), and onset-to-alert time (aOR for every minute less [≤55 min]: 0.96 [0.95–0.97]) were independently associated with direct EMS notification. Direct EMS call was independently associated with shorter onset-to-alert times (27 min [54–0.84]) and with shorter onset-to-needle times (−30 min [−51 to −10]). The association between direct EMS call and the onset-to-groin time was almost similar to the association with onset-to-needle time, though not statistically significant (univariable analysis: 23.7 min decrease [−103.7 to 56.2]).

Conclusion: More than half of all patients with suspected stroke do not call EMS directly but call their GP instead. Patients with higher FAST scores, alert outside office hours, and a rapid alert, more often call EMS directly. Patients who call EMS directly are treated with IVT 30 min faster than patients who call the GP first.

Trial registration number: Netherlands Trial Register: NL7387, (www.trialregister.nl).

1. Introduction

The effect of intravenous thrombolytics (IVT) and endovascular thrombectomy in patients with ischemic stroke declines strongly with increasing time to treatment [1,2]. Direct notification of emergency medical services (EMS) by patient or bystanders after onset of stroke symptoms helps to facilitate rapid arrival at the hospital and subsequent treatment. Over the past years, awareness campaigns have tried to

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https://doi.org/10.1016/j.clineuro.2022.107297
Received 17 January 2022; Received in revised form 24 April 2022; Accepted 14 May 2022
Available online 21 May 2022

shorten the onset-to-alert times and thereby onset-to-door times of patients with suspected stroke [3]. We aimed to investigate how often patients with suspected stroke call EMS first and to explore factors associated with direct EMS notification. Our secondary aim was to explore the association of direct EMS call with onset-to-alert-times, onset-to-needle times, and onset-to-groin times.

2. Materials and methods

We performed a secondary analysis with data from the Prehospital triage of patients with suspected stroke (PRESTO) study, a multicenter prospective observational cohort study that included patients with suspected stroke transported by two different ambulance services (Rotterdam-Rijnmond and Zuid-Holland Zuid) [4,5]. Patients were identified and included by paramedics in the field. Inclusion criteria for the PRESTO study were new neurological deficit defined as at least one point on the Face-Arm-Speech-Time (FAST) test, age 18 years or older, and serum blood glucose of at least 2.5 mmol/L. For the current analysis, we only included patients who presented at the emergency department within six hours after last-seen-well. This was because in the Netherlands, patients with suspected stroke who present within six hours after last-seen-well are almost always transported by ambulance and the proportion of patients who arrive at the emergency department with their own transport is negligible. Furthermore, we included only patients from the region Zuid-Holland Zuid, because the ambulance service in this region consistently noted the type of ambulance request (patient, GP or other) in the ambulance call report.

Region Zuid-Holland Zuid is populated with 480,000 inhabitants in an area of 720 square kilometers. In The Netherlands, GP guidelines state that an ambulance should be ordered with the highest urgency for patients with suspected stroke, if treatment would be possible within 6 h [6]. The ambulance should be ordered directly without a prior visit of the GP in these cases. In addition, the Dutch population is instructed to call EMS directly in patients with a positive FAST test by leaflets, banners, relevant websites, social media, and advertising on national television. For this study, paramedics performed a prehospital assessment just before or during transport [5]. Directly after arrival in the hospital, National Institutes of Health Stroke Scale (NIHSS) scores were assessed by the treating physician. Patient characteristics and data on time metrics were collected from ambulance call reports and through hospital chart review. The time of the EMS notification and the EMS notifier (primarily by patient or bystander, secondarily by GP or GP practice, or unknown) was extracted from ambulance call reports. We defined the onset-to-alert-time as the time from onset or last-seen-well to EMS notification.

2.1. Statistical analysis

We used univariable and multivariable binary logistic regression analyses to assess the association of patient characteristics with direct EMS notification. Variables for the univariable analysis were selected based on the clinical assumption of a potential association with direct EMS notification (age, sex, systolic blood pressure, medical history, pre-existent modified Rankin Scale, FAST score, NIHSS score, alert outside office hours and onset-to-alert time). For example, we included blood pressure because patients with extremely low or high blood pressure might be symptomatic and urge to alert EMS directly.

Variables with a P value of ≤ 0.15 in the univariable analysis were entered into the multivariable analysis. We assessed potential nonlinearity of continuous variables and the outcome with restricted cubic splines.

We used univariable and multivariable linear regression models to assess the association of direct EMS call with the onset-to-alert-time, onset-to-needle-time, and onset-to-groin time. Variables for the univariable analysis were selected based on the clinical assumption of a potential association with these time intervals (direct call to EMS, age, sex, systolic blood pressure, medical history, pre-existent modified Rankin Scale (mRS), FAST score, NIHSS score and alert outside office hours). We assessed and reported completeness of the data. For the regression analyses, missing data of the assessed variables were imputed using multiple imputation using additive regression, bootstrapping and predictive mean matching based on relevant covariates. All analyses were performed with R software (version 3.6.1) and RStudio (version 1.0.153).

3. Results

3.1. Patient characteristics

Between August 13, 2018, and September 2, 2019, 1334 patients were recruited in the PRESTO study, of which 1314 were available for the analysis (Supplementary Fig. 1). For this analysis, 878 patients were excluded (last-seen-well over six hours: n = 274, age < 18 years: n = 1, ambulance service Rotterdam-Rijnmond: n = 543, unknown first medical contact: n = 60). Of 436 included patients, 208 patients (48%) first notified EMS and 228 patients (52%) called the GP (Table 1). Median age of the included patients was 73 (interquartile range [IQR]: 64–84) for patients who called EMS directly and 74 (IQR: 66–84) for patients who called the GP first. The majority of patients had a medical history of diabetes mellitus, hypertension, or both: 140/208 (67%) of the patients who called EMS directly, and 156/228 (68%) of the patients who called the GP. Women less often called EMS directly, (84/201 [42%]), compared to men (124/235 [53%]). Patients who called EMS directly more often had an ischemic stroke due to LVO (32/208, 15%), compared to the patients who called the GP (9/228, 4%). Of the 60 patients with unknown first medical contact, patient characteristics were not significantly different from patients with known first medical contact (supplementary Table 1).

Table 1
Patient characteristics, stratified by first medical contact.

	Emergency number (n = 208)	General practitioner (n = 228)
Age	73 (64–84)	74 (66–84)
Sex (female)	84 (40%)	117 (51%)
Systolic blood pressure, mean (SD)	159 ± 27	159 ± 26
Medical history		
Atrial fibrillation	49 (24%)	31 (14%)
Hypertension	132 (64%)	150 (66%)
Hypercholesterolemia	150 (72%)	164 (72%)
Diabetes Mellitus	51 (25%)	51 (22%)
Ischemic stroke	67 (32%)	58 (25%)
Myocardial ischemia	25 (12%)	31 (14%)
Intracranial hemorrhage	2 (1%)	7 (3%)
Diabetes Mellitus and/or Hypertension	140 (67%)	156 (68%)
Pre-existent disability (mRS 3–5)	33 (16%)	48 (21%)
FAST test (0–3)	2 (1–2)	1 (0–2)
NIHSS score (0–42)	3 (0–7)	2 (0–5)
Alert outside office hours	97 (47%)	73 (32%)
Onset-to-alert time (minutes)	30 (9–75)	77 (34–170)
Onset-to-needle time (minutes)*	89 (64–141)	119 (95–203)
Onset-to-groin time (minutes)*	145 (105–225)	185 (127–277)
Diagnosis		
Ischemic stroke with LVO	32 (15%)	9 (4%)
Ischemic stroke	79 (38%)	102 (45%)
Intracranial hemorrhage	16 (8%)	14 (6%)
Transient ischemic attack	40 (19%)	46 (20%)
Stroke mimic	41 (20%)	57 (25%)

Data are median (interquartile range) or n (%), unless otherwise indicated. mRS: modified Rankin Scale. FAST: Face-Arm-Speech-Time NIHSS: National Institutes of Health Stroke Scale. LVO: large vessel occlusion. *Onset-to-needle-time in patients treated with intravenous thrombolysis (n = 139), onset-to-groin time in patients treated with endovascular thrombectomy (n = 29). Number of missings: Pre-existent disability: 23, NIHSS: 1, onset-to-alert time: 39

3.2. Associations with calling EMS directly

Sex, history of atrial fibrillation, history of ischemic stroke, history of intracranial hemorrhage, score on the FAST test, NIHSS, alert outside office hours, and onset-to-alert-time were at least weakly associated with calling EMS directly ($p \leq 0.15$) and were entered in the multivariable logistic regression model (Table 2). Onset-to-alert time was nonlinearly associated with calling EMS directly ($p < 0.0001$, Fig. 1), this remained after adjustment ($p < 0.0001$). None of the other associations with continuous variables were nonlinear. The score on the FAST test (adjusted odds ratio [aOR] for every point 1.45, 95% CI: 1.14–1.86), alert outside office hours (aOR 1.64, 95% CI: 1.05–2.55), and short onset-to-alert time (aOR for every minute ≤55 min: 0.96, 95% CI: 0.95–0.97) (Fig. 1) were independently associated with calling EMS directly.

3.3. Associations with the onset-to-alert time

Direct EMS call, history of diabetes mellitus and pre-existent disability had a p value ≤ 0.15 and were entered in the multivariable linear regression model (Table 3). Direct EMS call was independently associated with shorter onset-to-alert times (minus 27 min, 95% CI: −54 to −0.84). A history of diabetes mellitus was independently associated with a longer onset-to-alert time (plus 36.6 min, 95% CI: 2.3–70.9).

3.4. Associations with the onset-to-needle and onset-to-groin time

Direct EMS call, sex and pre-existent disability had a p value ≤ 0.15 and were entered in the multivariable linear regression model (Supplementary Table 2). Direct EMS call was independently associated with shorter onset-to-needle times (minus 30.3 min, 95% CI: −51.1 to −9.6, n = 139). Onset-to-needle times were 26.4 (95% CI: −47.6 to −5.2) minutes shorter for men than for women. Patients with higher pre-existent mRS had longer onset-to-needle times (12.6 min for each point increase, 95% CI: 3.6–21.6). The difference in onset-to-alert time of patients within this subgroup was 65 min (95% CI: 31–142) for women, versus 37 min (95% CI: 17–73) for men.

The association between direct EMS call and the onset-to-groin time was almost similar to the association with onset-to-needle time, but not statistically significant (univariable analysis: 23.7 min decrease, 95% CI: −103.7 to 56.2, p = 0.55, n = 29).

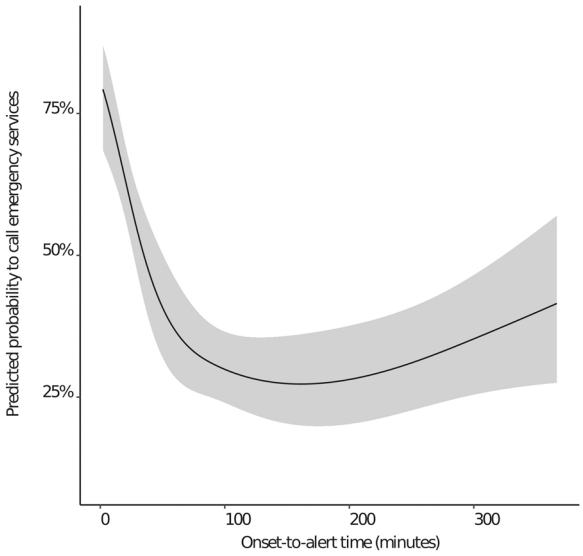

Fig. 1. Relation of the onset-to-alert time to the probability to call the emergency number. The relation was assessed with restricted cubic splines, p-likelihood ratio test < 0.0001.

4. Discussion

We found that most patients with suspected stroke do not call EMS first after noticing stroke symptoms. Directly calling EMS was observed more frequently in patients with higher scores on the FAST test, notification outside office hours, and when medical help was sought faster. Patients with diabetes mellitus waited longer to alert. Patients who called EMS directly were treated with IVT 30 min faster than patients who called the GP first.

In the Netherlands, GPs, also called “family doctors”, are often well known to the patient and easily approachable for patients. This could explain why patients often contact the GP first. Patients with higher FAST scores more often called EMS first, which could be explained by the (Dutch) awareness campaigns that focus on FAST symptoms. Besides, even without knowledge of the FAST test, abnormal FAST symptoms can easily be recognized and urge patients or bystanders to alert the EMS. The NIHSS score was not associated with direct EMS notification or the onset-to-alert time. This may seem contradictory to the finding that the FAST score was associated with direct EMS call, and

Table 2
Factors related to calling the emergency medical services directly, univariable and multivariable logistic regression analysis.

	Univariable analysis - OR (95% CI)	p-value	Multivariable analysis - OR (95% CI)	p-value
Age (years)	0.99 (0.98–1.01)	0.41	–	–
Sex (male)	1.56 (1.06–2.27)	0.02	1.42 (0.93–2.16)	0.10
Systolic blood pressure (mmHg)	1.00 (0.99–1.01)	0.95	–	–
History of atrial fibrillation	1.96 (1.19–3.22)	0.008	1.69 (0.97–2.92)	0.06
History of hypertension	0.90 (0.61–1.34)	0.61	–	–
History of hypercholesterolemia	1.01 (0.66–1.53)	0.97	–	–
History of diabetes mellitus	1.13 (0.72–1.76)	0.60	–	–
History of ischemic stroke	1.39 (0.92 – 2.11)	0.12	1.28 (0.04–1.40)	0.30
History of myocardial ischemia	0.87 (0.49–1.53)	0.62	–	–
History of intracranial hemorrhage	0.31 (0.06–1.49)	0.14	0.25 (0.04–1.42)	0.11
Pre-existent modified Rankin Scale (0–5)	0.90 (0.78–1.04)	0.16	–	–
FAST test (0–3)	1.49 (1.23–1.79	< 0.0001	1.45 (1.14–1.86)	0.003
NIHSS (0–42)	1.02 (1.00–1.06)	0.10	0.99 (0.75–1.17)	0.57
Alert outside office hours	1.86 (1.26–2.74)	0.002	1.64 (1.05–2.55)	0.03
Onset-to-alert time minutes (<55 min)	0.96 (0.95–0.98)	< 0.0001	0.96 (0.95–0.97)	< 0.0001
Onset-to-alert time minutes (>55 min)	0.99 (0.99–1.00)	0.28	1.00 (0.99–1.00)	0.22

OR: odds ratio. CI: Confidence Interval. FAST: Face-Arm-Speech-Time. NIHSS: National Institutes of Health Stroke Scale. Outside office hours was defined as Monday to Friday between 17:00 and 08:00, weekends and public holidays.

Table 3
Factors related to the onset-to-alarm time, univariable and multivariable linear regression analysis.

	Univariable analysis - ß (95% CI)	p-value	Multivariable analysis - ß (95% CI)	p-value
Direct call to emergency service	-27.4 (−54.1 to −0.7)	0.04	-27.0 (−54.0 to −0.84)	0.04
Age (years)	0.3 (−0.6 to 1.3)	0.49	–	–
Sex (male)	-4.8 (−32.9 to 23.3)	0.74	–	–
Systolic blood pressure (mmHg)	0.07 (−0.4 to 0.6)	0.77	–	–
History of atrial fibrillation	-5.4 (−44.4 to 33.7)	0.79	–	–
History of hypertension	14.1 (−15.4 to 43.7)	0.35	–	–
History of hypercholesterolemia	17.0 (−16.6 to 50.5)	0.32	–	–
History of diabetes mellitus	39.9 (6.5 – 73.3)	0.02	36.6 (2.3 – 70.9)	0.04
History of ischemic stroke	-15.6 (−44.6 to 13.5)	0.29	–	–
History of myocardial ischemia	0.9 (−45.0 to 46.8)	0.97	–	–
History of intracranial hemorrhage	-20.2 (−111.4 to 70.9)	0.66	–	–
Pre-existent modified Rankin Scale (0–5)	9.0 (−1.1 to 19.1)	0.08	5.2 (−5.2 to 15.6)	0.32
FAST test (0–3)	3.5 (−9.9 to 16.9)	0.61	–	–
NIHSS (0–42)	-0.03 (−2.1 to 2.1)	0.98	–	–
Alert outside office hours	12.4 (−15.6 to 40.5)	0.38	–	–

CI: Confidence Interval. FAST: Face-Arm-Speech-Time. NIHSS: National Institutes of Health Stroke Scale. The reported ß is the coefficient of the analysis and indicates the change in onset-to-alert time in minutes for the presence or point increase of the assessed variable. Outside office hours was defined as Monday to Friday between 17:00 and 08:00, weekends and public holidays.

might be because FAST symptoms are more easily recognized than other items of the NIHSS. Outside office hours, EMS are more often called, most likely because the GP practice is closed, although there is a regional GP on call. The association of shorter onset-to-alert times and alerting EMS directly implies that patients who are aware of the urgency to alert, call EMS directly. Patients with diabetes mellitus wait longer to alert, maybe because they assume they have hypoglycemia or hyperglycemia, focus on their glucose levels first and wait for spontaneous improvement. However, this could also be a coincidental finding based on multiple testing.

Few studies have investigated determinants of calling EMS directly, but these studies confirm that the GP is often contacted first [7,8]. The remarkable finding that even patients with previous stroke do not always call the EMS, has been described in other studies [8,9]. Another Dutch study confirmed that outside office hours, patients more often alerted EMS directly [7]. Contrary to the findings of one other study, we did not find an association between NIHSS score and direct EMS notification [8]. However, that study only included patients with ischemic stroke or transient ischemic attack, which may have strengthened the association. An association with onset-to-alarm time and diabetes has not been described previously. However, none of the studies assessed onset-to-alert time as continuous variable but as dichotomized variable, which might have resulted in the loss of information [9–11]. Furthermore, in the subgroup of patients that were treated with IVT, we demonstrated that directly calling EMS resulted in shorter onset-to-needle times. Even more remarkable was that women treated with IVT had longer onset-to-needle times compared to men. This is largely explained by the difference in onset-to-alert time between women and men in this subgroup. Unfortunately, our study does not provide an explanation why women waited longer to alert.

The strength of our study is that we included patients with suspected stroke who were recruited by paramedics. However, our study has some limitations. Most importantly, we restricted to patients who presented within 6 h after symptom onset, and all of our patients were transported by the ambulance. Therefore, with this study, we cannot draw any conclusions regarding decision-making of patients who wait over six hours to call for help, or of patients who do not seek help at all. For patients that contacted the GP first, we have no information about the exact time the GP was alerted, but only the time of the GP notification to EMS. Even though GPs are instructed to alert EMS directly, this process will be somewhat delayed and resulted in a minor overestimation of the onset-to-alert time. Due to the nature of the available data, we needed to restrict our study to one region, which is supposed to be less urban compared to the other ambulance region. This might have influenced our results, as patients from rural areas seem to be more hesitant to call EMS [11]. Primary care systems could be differently organized in other countries. However, the conclusions from this research are representative for other countries with a similar primary care system. Finally, we had no knowledge regarding potentially contributing factors to the notification type or time, such as the level of education, living alone, whether the patient or a bystander sought help or the patient's considerations before notification. This could have provided additional insight of determinants to call the EMS directly.

Older studies showed mass media interventions have limited impact on patient decision-making in seeking help [3]. However, these studies should be interpreted with care due to (methodological) weaknesses. For example, these studies did not use a control group or did not perform a before-and-after evaluation [3,11]. A recent French study investigated the impact of the ReACT campaign on the number of EMS calls and public stroke knowledge in an intervention county and control county [12]. This study showed an increase in EMS calls after the implementation, but no significant increase in symptom knowledge or decrease in time from onset-to-alert. Other studies have shown that despite knowledge of stroke symptoms, patients often do not recognize the urgency to seek help [13,14]. However, a time-series study from the United Kingdom showed a significant reduction in delay to seek help in patients with severe stroke after the implementation and regular recurrence of television campaigns on the FAST test [15]. This effect was mostly attributable to an increase in patients directly contacting EMS. Unfortunately, this result was not seen in patients with transient ischemic attack or minor stroke during the same time period [16]. It might be helpful to combine such repetitive media campaigns with more direct or individualized education. In our study, most patients with suspected stroke had a medical history that warrants follow-up by their GP for annual assessment of cardiovascular risk factors. This provides an opportunity for systematic education about how to act on cardiovascular events in general and stroke in particular.

5. Conclusion

More than half of all patients with suspected stroke do not call EMS directly but call their GP instead. Patients with higher FAST scores, alert outside office hours, and a rapid alert, more often call EMS directly. Patients who call EMS directly are treated with IVT 30 min faster than patients who call the GP first.

Statement of Ethics

This research was conducted in accordance with the World Medical Association Declaration of Helsinki. The Institutional Review Board of the Erasmus MC University Medical Center Rotterdam has reviewed the study protocol and confirmed that the Dutch Medical Research Involving Human Subjects Act was not applicable (MEC-2018-1012). Therefore, ethical approval was not required. Because this study met the exceptions of informed consent regulations (Dutch Agreement on Medical

Treatment Act, 7:458 BW), the need for informed consent was waived.

Funding

This study was funded by the BeterKeten Collaboration (the Netherlands) and Theia Foundation (Zilveren Kruis, the Netherlands). The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

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Acknowledgements

We would like to thank all PRESTO Investigators for their assistance in this research:

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Declaration of Competing Interest

Diederik Dippel and Aad van der Lugt report funding from the Dutch Heart Foundation, Brain Foundation Netherlands, The Netherlands Organisation for Health Research and Development, Health Holland Top Sector Life Sciences & Health, and unrestricted grants from Penumbra Inc., Stryker, Stryker European Operations BV, Medtronic, Thrombolytic Science, LLC and Cerenovus for research, all paid to institution. Bob Roozenbeek reports funding from the Dutch Heart Foundation and The Netherlands Organisation for Health Research and Development, paid to institution. Pieter Jan van Doormaal reports funding from Stryker, paid to institution and an unrestricted fee from Bayer. All other authors declare no conflict of interest.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.clineuro.2022.107297.

References

[1] K.R. Lees, E. Bluhmki, R. von Kummer, T.G. Brott, D. Toni, J.C. Grotta, et al., Time to treatment with intravenous alteplase and outcome in stroke: an updated pooled analysis of ECASS, ATLANTIS, NINDS, and EPITHET trials, Lancet 375 (9727) (2010) 1695–1703.

[2] J.L. Saver, M. Goyal, A. van der Lugt, B.K. Menon, C.B. Majoie, D.W. Dippel, et al., Time to treatment with endovascular thrombectomy and outcomes from ischemic stroke: a meta-analysis, JAMA 316 (12) (2016) 1279–1288.

[3] J. Lecouturier, H. Rodgers, M.J. Murtagh, M. White, G.A. Ford, R.G. Thomson, Systematic review of mass media interventions designed to improve public recognition of stroke symptoms, emergency response and early treatment, BMC Public Health 10 (2010) 784.

[4] E. Venema, M.H.C. Duvekot, H.F. Lingsma, A.D. Rozeman, W. Moudrous, F. H. Vermeij, et al., Prehospital triage of patients with suspected stroke symptoms (PRESTO): protocol of a prospective observational study, BMJ Open 9 (7) (2019), e028810.

[5] M.H.C. Duvekot, E. Venema, A.D. Rozeman, W. Moudrous, F.H. Vermeij, M. Biekart, et al., Comparison of eight prehospital stroke scales to detect intracranial large-vessel occlusion in suspected stroke (PRESTO): a prospective observational study, Lancet Neurol. 20 (3) (2021) 213–221.

[6] Genootschap NHNH. NHG-Standaard Beroerte, 2018.

[7] T.T.M. Nguyen, N.D. Kruyt, J.G.J. Pierik, C.J.M. Doggen, P. van der Lugt, S.A. V. Ramessersing, et al., Stroke patient's alarm choice: general practitioner or emergency medical services, Acta Neurol. Scand. 143 (2) (2021) 164–170.

[8] K.W. Faiz, A. Sundseth, B. Thommessen, O.M. Ronning, Factors related to decision delay in acute stroke, J. Stroke Cerebrovasc. Dis. 23 (3) (2014) 534–539.

[9] J. Fladt, N. Meier, S. Thilemann, A. Polymeris, C. Traenka, D.J. Seiffge, et al., Reasons for prehospital delay in acute ischemic stroke, J. Am. Heart Assoc. 8 (20) (2019), e013101.

[10] K.W. Faiz, A. Sundseth, B. Thommessen, O.M. Ronning, Prehospital delay in acute stroke and TIA, Emerg. Med. J. 30 (8) (2013) 669–674.

[11] M.N. Ungerer, L. Busetto, N.H. Begli, K. Riehle, J. Regula, C. Gumbinger, Factors affecting prehospital delay in rural and urban patients with stroke: a prospective survey-based study in Southwest Germany, BMC Neurol. 20 (1) (2020) 441.
[12] J. Haesebaert, C. Laude, A. Termoz, E. Bravant, N. Perreton, T. Bony, et al., Impact of a theory-informed and user-centered stroke information campaign on the public's behaviors, attitudes, and knowledge when facing acute stroke: a controlled before-and-after study, BMC Public Health 20 (1) (2020) 1712.
[13] E. Zock, H. Kerkhoff, R.P. Kleyweg, T.B. van Bavel-Ta, S. Scott, N.D. Kruyt, et al., Help seeking behavior and onset-to-alarm time in patients with acute stroke: sub-study of the preventive antibiotics in stroke study, BMC Neurol. 16 (1) (2016) 241.
[14] A. Hickey, L. Mellon, D. Williams, E. Shelley, R.M. Conroy, Does stroke health promotion increase awareness of appropriate behavioural response? Impact of the face, arm, speech and time (FAST) campaign on population knowledge of stroke risk factors, warning signs and emergency response, Eur. Stroke J. 3 (2) (2018) 117–125.
[15] F.J. Wolters, N.L. Paul, L. Li, P.M. Rothwell, S. Oxford Vascular, Sustained impact of UK FAST-test public education on response to stroke: a population-based time-series study, Int. J. Stroke 10 (7) (2015) 1108–1114.
[16] F.J. Wolters, L. Li, S.A. Gutnikov, Z. Mehta, P.M. Rothwell, Medical attention seeking after transient ischemic attack and minor stroke before and after the UK Face, Arm, Speech, Time (FAST) public education campaign: results from the oxford vascular study, JAMA Neurol. 75 (10) (2018) 1225–1233.