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AUTHOR(S)

Lisa Mellon, Frank Doyle, Daniela Rohde, David Williams, Anne Hickey

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REVIEW

Stroke warning campaigns: delivering better patient outcomes? A systematic review

Lisa Mellon[1]
Frank Doyle[1]
Daniela Rohde[1]
David Williams[2]
Anne Hickey[1]

[1]Department of Psychology, Royal College of Surgeons in Ireland, Dublin, Ireland; [2]Department of Geriatric and Stroke Medicine, Royal College of Surgeons in Ireland, Dublin, Ireland

Background: Patient delay in presenting to hospital with stroke symptoms remains one of the major barriers to thrombolysis treatment, leading to its suboptimal use internationally. Educational interventions such as mass media campaigns and community initiatives aim to reduce patient delays by promoting the signs and symptoms of a stroke, but no consistent evidence exists to show that such interventions result in appropriate behavioral responses to stroke symptoms.

Methods: A systematic literature search and narrative synthesis were conducted to examine whether public educational interventions were successful in the reduction of patient delay to hospital presentation with stroke symptoms. Three databases, MEDLINE, CINAHL, and PsycINFO, were searched to identify quantitative studies with measurable behavioral end points, including time to hospital presentation, thrombolysis rates, ambulance use, and emergency department (ED) presentations with stroke.

Results: Fifteen studies met the inclusion criteria: one randomized controlled trial, two time series analyses, three controlled before and after studies, five uncontrolled before and after studies, two retrospective observational studies, and two prospective observational studies. Studies were heterogeneous in quality; thus, meta-analysis was not feasible. Thirteen studies examined prehospital delay, with ten studies reporting a significant reduction in delay times, with a varied magnitude of effect. Eight studies examined thrombolysis rates, with only three studies reporting a statistically significant increase in thrombolysis administration. Five studies examined ambulance usage, and four reported a statistically significant increase in ambulance transports following the intervention. Three studies examining ED presentations reported significantly increased ED presentations following intervention. Public educational interventions varied widely on type, duration, and content, with description of intervention development largely absent from studies, limiting the potential replication of successful interventions.

Conclusions: Positive intervention effects were reported in the majority of studies; however, methodological weaknesses evident in a number of studies limited the generalizability of the observed effects. Reporting of specific intervention design was suboptimal and impeded the identification of key intervention components for reducing patient delay. The parallel delivery of public and professional interventions further limited the identification of successful intervention components. A lack of studies of sound methodological quality using, at a minimum, a controlled before and after design was identified in this review, and thus studies incorporating a rigorous study design are required to strengthen the evidence for public interventions to reduce patient delay in stroke. The potential clinical benefits of public interventions are far-reaching, and the challenge remains in translating knowledge improvements and correct behavioral intentions to appropriate behavior when stroke occurs.

Keywords: acute stroke treatment, prehospital delay, onset to door times, public education, professional education, interventions

Correspondence: Lisa Mellon
Department of Psychology, Division of Population Health Sciences, Royal College of Surgeons in Ireland, 123 St Stephens Green, Dublin 2, Ireland
Tel +353 1402 2748
Fax +353 1402 2764
Email lisamellon@rcsi.ie

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Introduction

Thrombolysis with tissue plasminogen activator within a 3- to 4.5-hour window following onset of ischemic stroke is associated with improved patient outcome and reduction in disability,[1] with the chances of a favorable outcome falling twofold for every 90-minute delay in treatment.[2] Despite its proven efficacy, provision rates remain suboptimal internationally.[3] Interventions targeted at the public aim to reduce patient delay in presentation with stroke symptoms, and thus play an important role in improving treatment rates for thrombolysis in ischemic stroke. Patient delay in accessing medical care has been cited as the biggest barrier to thrombolysis treatment for ischemic stroke,[4–6] with prehospital delays estimated to account for up to 68% of total delay from onset to treatment.[7] The aim of public-focused educational interventions is to reduce patient delay by educating the public of the common signs and symptoms of stroke and the correct course of action should symptoms occur.

Much of the published literature to date that examines the effectiveness of public educational interventions is concerned with nonbehavioral intervention end points where no definitive behavior occurs, such as stroke knowledge and intentions to call emergency medical services (EMS).[8–11] However, the association between stroke knowledge and improved time to presentation is poor,[12–14] and recent guidelines highlight that the only acceptable outcome of a health intervention is a behavioral outcome or a measurable consequence of the target behavior:[15] ie, where the target behavior occurs following the intervention. Outcomes of a public stroke education intervention need to provide a measure of the clinical impact of the intervention. Measurable behavioral outcomes of an intervention, such as stroke onset to door (OTD) times, or measurable consequences such as thrombolysis rates, emergency department (ED) presentations with stroke symptoms, or ambulance dispatches help provide an estimate of the real effectiveness of an intervention of this type. The aim of this review was to examine the effectiveness of interventions that aim to reduce prehospital delay by systematically reviewing studies containing such behavioral end points.

Methods

Search strategy

Three electronic databases, MEDLINE, CINAHL, and PsycINFO, were searched from database start date to October 24, 2014 for educational interventions targeted at the public that aim to reduce prehospital delay and that had a measurable behavioral outcome. The key search term "stroke" was accompanied with all combinations of the terms "thrombolysis", "tPA", "actilyse", "alteplase", "delay", "intervention", "education", "paramedic", "ambulance", "emergency", "awareness", "campaign", and "time". The Google Scholar search engine and reference lists for included papers were additionally searched in order to identify studies that may not have been identified through the database searches. Reference lists for identified review papers were scanned and cross-referenced with studies identified from the primary search. Two authors independently screened and reviewed abstracts and titles for relevant papers. Disagreements were discussed with a third reviewer.

Inclusion and exclusion criteria

Studies were included if a measurable behavioral outcome of a public educational intervention to reduce prehospital delay was assessed. Randomized controlled trials (RCTs), non-RCTs, and prospective, retrospective, and cross-sectional studies were included. Studies were excluded if the intervention outcome was stroke knowledge, attitudes, behavioral intentions, or any other nonbehavioral outcome. Studies were also excluded if the article was a review or discussion paper, if an English or German translation of the paper was not available, or if the article was not published in full in a peer-reviewed journal.

Data extraction and synthesis

The following data were extracted: author, publication year, location and setting, sample characteristics, intervention duration and content, behavioral outcomes assessed, and intervention results. Given the heterogeneity of study types, meta-analysis was not indicated, and a qualitative narrative synthesis was conducted.

Outcomes

The main outcomes of interest were reduction in OTD time, thrombolysis rates, activation of ambulance transports, ED presentations with stroke symptoms, and patient mortality.

Quality assessment

Critical appraisal of primary studies is an essential feature of systematic reviews; however, no consensus exists on the "gold standard" appraisal method for assessing methodological quality.[16] The Crowe Critical Appraisal Tool (CCAT)[17] was selected for the purposes of this review. It is a generic critical appraisal tool that has been reported to be simple to implement and applicable to all research designs in health, with obtained scores being directly comparable. Studies are scored from 0 to 5 on eight dimensions: preamble,

introduction, design, sampling, data collection, ethical matters, results, and discussion. Each dimension includes up to three subcategories with a number of descriptors marked as present, absent, or not applicable. The total score, ranging from 0 to 40, may be displayed as a percentage. The CCAT demonstrates good reliability and[18,19] construct validity,[20] comprehensively assesses the key aspects of research, and can be utilized across different research designs.

Results

Database searches identified 4,561 citations, with 3,006 remaining after duplicate removal. Three studies were additionally identified through Google Scholar searches. Fifteen studies met the inclusion criteria. Figure 1 outlines the screening process and the reasons for study exclusion.

Table 1 displays the main characteristics of the final studies. A single cluster RCT[21] was identified, and two time series design studies[22,23] were identified. Three studies[24–26] were controlled before and after studies, and five studies[27–31] were uncontrolled before and after studies. There were two retrospective observational studies[32,33] and two prospective observational studies.[34,35] The main outcome of interest, reduction in prehospital delay, was assessed in 13 of the studies.[21,23–31,34,35] Rates of thrombolysis were assessed in eight studies.[21,22,24,26,29,31,33,34] Five studies[23,25,29,30,32] examined ambulance dispatches for stroke, three studies[22,23,28] examined ED presentations, and two studies[21,26] examined patient mortality as behavioral indicants of intervention effectiveness.

Study quality was assessed independently by two reviewers using the CCAT, with disagreements discussed with a third reviewer. All papers were rated on the eight dimensions of the CCAT, and a total score for each study was derived from the average score of the independent ratings and expressed as a percentage. Overall, the methodological quality was mixed. As only one study was identified as an RCT design, the majority of studies lacked quality in research design, management of bias, and sampling. Data collection

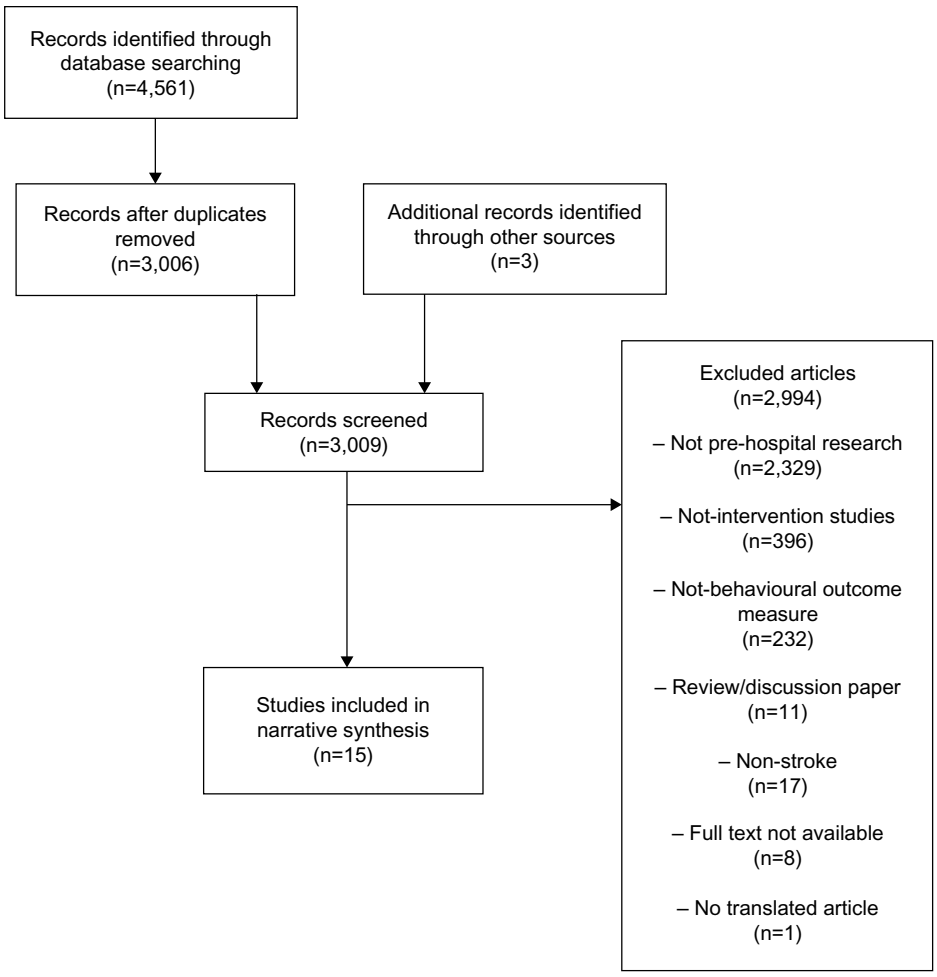


Figure 1 Flow chart of studies screened, excluded (with reasons), and included in the review.

Table 1 Summary of data extracted from studies included in review

Reference, country	Sample description	Sample size	Intervention duration	Intervention type	Study design	Behavioral outcome	Results
Addo et al,[33] UK	All stroke cases with an OTD time in the South London Stroke Register	1,392 strokes 2002–2010	1 year	Public education	Retrospective observational study	Time to presentation Thrombolysis rate	No change in prehospital delay times or thrombolysis rates
Alberts et al,[27] USA	Patients with cerebral infarction, stroke-in-evolution, ICH, or SAH in one hospital	290 preintervention 189 postintervention	4 months	Public and professional education	Uncontrolled before and after study	Presentation under 24 hours	Increase from 40% to 85% ($P<0.001$)
Barsan et al,[35] USA	Stroke patients presenting within 24 hours in 12 hospitals	1,116 cases with a recorded OTD time	Not reported	Public and professional education	Prospective observational study	Time to presentation	Mean decline in time to presentation from 3.2 hours to 1.5 hours ($P<0.032$)
Bray et al,[32] Australia	All ambulance dispatches for stroke in metropolitan Melbourne	Not reported	1 week per year, 4 years	Public education	Retrospective observational study	Proportion of ambulance dispatches for stroke	Significant increase in dispatches: 2007: 2.62%–3% ($P=0.006$) 2008: 2.62%–3.05% ($P=0.003$) 2009: 2.7%–3.09% ($P=0.00$)
Chen et al,[25] People's Republic of China	All stroke cases with an OTD time in one city hospital	Year 1 = 227 (113 vs 114) Year 2 = 253 (145 vs 108) Year 3 = 232 (107 vs 125)	28 months	Public and professional education	Controlled before and after study	Time to presentation Proportion of ambulance dispatches for stroke	Significant median OTD time decrease in intervention group from 180 minutes to 79 minutes ($P<0.001$) Significant increase in activation from 50.4% in 2008 to 60.7% in intervention group ($P=0.02$)
Flynn et al,[22] UK	Hospital Episode Statistics for England; data from the Safe Implementation of Thrombolysis in Stroke UK database (27 hospitals)	353,305 admissions for stroke; 3,450 thrombolysis cases	3 waves: 8 months, 4 months, 12 months	Public education	Interrupted time series design	Overall admissions with stroke ED admissions with stroke Admissions via GP Thrombolysis rate	General increase in overall admissions with stroke over study period–significant level trend increase for wave 1 only (505 cases, 95% CI 75–935) General increase in ED admissions with stroke over study period–significant level trend increase for wave 1 only (451 cases, 95% CI 26–875) General decline in ED admissions with stroke over study period–significant level trend decline following wave 3 only (–19 cases, 95% CI –29 to –9) General increase in thrombolysis rates over study period–significant monthly activity following wave 1 only (3 cases per month, 95% CI 1–4)
Hodgson et al,[28] Canada	ED attendances for stroke in 11 hospitals	12,534	Two waves: 9 months, 8 months	Public education	Uncontrolled before and after study	Total number of stroke ED visits Presentation <5 hours Presentation <2.5 hours	Significant increase in mean ED visits ($P<0.001$) Increase in presentations <5 hours ($P<0.001$, 15% of variance) Increase in presentations <2.5 hours ($P<0.001$, 5% of variance)

Luiz et al,[30] Germany	Stroke patients admitted directly from EMS to stroke unit	101 preintervention 120 postintervention	12 months	Public and professional education	Uncontrolled before and after study	Time to presentation EMS activation time EMS use	Reduction in median delay time from 368 minutes to 140 minutes ($P<0.01$) Reduction in median activation time from 263 minutes to 54 minutes ($P<0.01$) Increased use from 28.8% preintervention to 33.3% postintervention ($P<0.01$)
Mellon et al,[23] Ireland	All ED admissions with stroke symptoms over 12 months to two hospitals	870 ED admissions with stroke symptoms	Three waves; 3 weeks	Public education	Interrupted time series design	ED admissions Time to presentation EMS use	Increased ED admissions during and following wave 1 (pre =11; during =31.3; post =19.6, $P<0.001$). No change for waves 2 or 3 No change in trends for time to presentation No change in EMS use
Morgenstern et al,[24] USA	All stroke admissions to 10 hospitals	424 preintervention 765 postintervention	15 months	Public and professional education	Controlled before and after study	Thrombolysis rate Time to presentation	Intervention group: increase from 2.21% to 8.65% ($P=0.02$) for ischemic stroke patients Control group: increase from 0.71% to 0.86% (P=NS) Overall increase in proportion of presentations under 2 hours: intervention group 3.6% increase ($P=0.55$), control group 6% increase ($P=0.28$)
Müffelmann et al,[31] Germany	All acute stroke admissions to a neurology clinic	126 preintervention 162 postintervention	6 months	Public education	Uncontrolled before and after study	Time to presentation Admission <4 hours Thrombolysis rate	Reduction in median delay time from 8 hours to 5 hours ($P<0.01$) Increase from 36.6% to 46.9% (P=not reported) Increase from 1 case to 9 cases postcampaign
Müller-Nordhorn et al,[21] Germany	All stroke and TIA admissions to 3 hospitals	647 interventions 741 control	1 year	Public education	Cluster randomized controlled trial	Time to presentation Thrombolysis rate Mortality	27% reduction in delay time for women only (acceleration factor log-normal survival regression model =0.73) 2.9% intervention group, 2.3% control group; $P=0.31$) 3.2% intervention group, 2.6% control group ($P=0.49$)

(*Continued*)

Table 1 (*Continued*)

Reference, country	Sample description	Sample size	Intervention duration	Intervention type	Study design	Behavioral outcome	Results
Schmidt et al,[34] Germany	Consecutive stroke admissions to one hospital center	146	6 months	Public education	Prospective observational study	Time to presentation Admission <3 hours Thrombolysis rate	Reduction in delay time from 12 hours to 3.2 hours (*P*=NS) Proportional increase by month July–December: 35%; 28%; 39%; 40%; 43% Increase from 0.83 to 2.42 (*P*=not reported)
Sun et al,[26] People's Republic of China	All stroke admissions in two communities, each with a population of approximately 50,000	227 interventions 247 control	50 months	Public and professional intervention	Controlled before and after study	Time to presentation Admission <3 hours Thrombolysis rate	Reduction in delay time in intervention group (8.3 hours vs 10.5 hours), (*P*=0.018) Proportion arriving within 3 hours lower in intervention group (48% vs 21.5%, *P*<0.001) Increased thrombolysis rate in control group (9.3% vs 4.5%, *P*=0.029)
Wojner-Alexandrov et al,[29] USA	All stroke and TIA admissions to 3 hospitals	446 preintervention 1,072 active intervention	12 months	Public and professional education	Uncontrolled before and after study	Ambulance transports for stroke Time to presentation<2 hours Thrombolysis rate	Increased ambulance transports from 59.8% to 68.7% (*P*<0.001) Increase in arrival <2 hours from 58% to 62% (*P*=0.002) Rate increase in 4 centers (4.7%–17.2%; 0%–6.8%; 5.9%–9.8%; 0%–8.1%) Rate decrease in 2 centers (19.4%–15.8%; 14.3%–8.3%)

Abbreviations: OTD, onset to door time; ICH, intracranial hemorrhage; SAH, subarachnoid hemorrhage; ED, emergency department; GP, general practitioner; CI, confidence interval; EMS, emergency medical services; NS, not significant; TIA, transient ischemic attack; waves, campaign wave with active advertising.

methods and comprehensive reporting of results were also identified as poor quality for some studies.

Study population

Data collection settings were the hospital ED in the majority of cases, with information obtained mainly from patient medical records or hospital stroke registries. One study[35] obtained additional data from the patient and/or family, with another study[32] retrospectively examining patients with an ambulance dispatch for stroke in an urban ambulance service over a 10-year period. In three studies,[27,31,35] patients were recruited as part of a thrombolysis trial.

Intervention characteristics

Intervention content

Table 2 summarizes the content of the interventions described in the included studies. Intervention descriptions varied considerably between studies. Five studies described mass media campaigns aimed at the general public, all using a specific slogan to promote stroke awareness. The Australian,[32] UK,[22,33,36] and Irish[23] studies described the FAST (Face, Arm, Speech, Time) campaign, which highlights three main symptoms of stroke and the need to contact EMS immediately. The Canadian study[28] utilized the SUDDENS campaign, highlighting 'sudden' onset of weakness, trouble speaking, vision, headache, and/or dizziness. The remaining studies described both public and professional education campaigns that were broadcast at a local and regional level. The professional campaigns focused on reducing prehospital and in-hospital delays, from initiation of EMS contact to treatment in the acute hospital setting. These were aimed at professionals involved in acute stroke care, including paramedics, ED staff, and general practitioners. Three studies[24,26,27] used educational messages that described thrombolysis treatment, emphasizing the time-dependent nature of the treatment in addition to its efficacy. The RCT[21] posted educational packs to inhabitants aged over 50 years in 48 randomized zip codes, each containing a personalized letter outlining signs and symptoms of stroke, a bookmark, and a sticker outlining the main symptoms and EMS contact details.

Intervention development

Only the intervention by Morgenstern et al[24] comprehensively described the stages of development of the intervention. The community intervention component involved role-modeling of the appropriate response to stroke symptoms by publicly advertising stroke survivors in the community and their successful experience of thrombolysis. The purpose of community role-modeling was to demonstrate that immediate stroke response was associated with better outcome. Morgenstern et al[24] also developed a local advisory board and conducted a telephone survey (n=656) for the purposes of identifying factors related to intention to react rapidly to signs of stroke. The authors additionally conducted focus groups with stroke survivors to assess factors that contributed to delay in time to hospital presentation with stroke. The professional education component involved systems change in hospitals, change of perceived norms in the medical community, and reinforcement of behavior change.

Patient delay times

Thirteen studies examined change in patient prehospital delay times as an outcome following a public educational intervention. The majority of studies reported statistically significant effects in terms of reducing patient delay, with ten studies reporting a statistically significant reduction in prehospital delay following the intervention, with the magnitude of change varying per study.

RCT study

The RCT[21] reported a statistically significant reduction of 27% in prehospital delay in women in the intervention group, with no change observed in men.

Controlled before and after studies

The controlled study by Morgenstern et al[24] involving community and professional intervention in the US reported an overall decrease in prehospital delay; however, the decrease was general and not specific to the intervention group. Hence, the public intervention was not associated with this overall decrease. Two Chinese controlled before and after studies reported significant reductions in patient delay. The study by Chen et al[25] evidenced a significant yearly decline in median OTD time from 280 minutes in 2008 to 79 minutes in 2010 in the intervention community, with no changes reported in the controlled community. Sun et al[26] reported a reduction of 2.2 hours in the intervention group for OTD time, with a significantly greater proportion (26%) in the intervention group arriving to hospital in less than 3 hours.

Time series study

An Irish time series analysis by Mellon et al[23] reported no effect of the FAST campaign on OTD time over a 12-month period.

Table 2 Intervention content of included studies

Reference, country	Intervention type	Intervention development	Importance of immediate action	Promotion of signs and symptoms of stroke	Importance of calling emergency services	Emphasis of effective treatments such as thrombolysis	Use of a specific slogan	Professional education
Addo et al,[33] UK	Mass media campaign (television)		+	+	+		+	
Alberts et al,[27] USA	Community education: radio features on thrombolysis, call-in talk radio talk shows, print media Professional education: in-service training, educational lectures, informational mailings, visits by study investigators, paramedic education		+	+	+	+		+
Barsan et al,[35] USA	Community education: television, radio, PSA, print media Professional education: specialist presentations, mailing to local and regional physicians, study explanation to paramedic personnel			+	+			+
Bray et al,[32] Australia	Mass media campaign (television, radio, print media)		+	+	+		+	
Chen et al,[25] People's Republic of China	Community education: print media home delivered once a year for 3 years, public lectures Professional education: specialist presentations, mailing to local and regional physicians, study explanation to paramedic personnel		+	+	+			+
Flynn et al,[22] UK	Mass media campaign (television)		+	+	+		+	
Hodgson et al,[28] Canada	Mass media campaign (television, radio, PSA, print media)		+	+	+		+	
Luiz et al,[30] Germany	Community education: print media, Q&A at public events, information displays in pharmacies Professional education: medical and paramedic education, adaptations to emergency services protocols		+		+			+
Mellon et al,[23] Ireland	Mass media campaign (television)		+	+	+		+	
Morgenstern et al,[24] USA	Community education: television, radio, PSA, print media, face-to-face education Professional education: in-hospital systems education, continuing medical education, mock 'stroke codes'	+	+	+	+	+		+
Müffelmann et al,[31] Germany	Community education: television, radio, print media, public lectures, establishment of a stroke emergency number Professional education: GP education		+	+	+			+
Müller-Nordhorn et al,[21] Germany	Individual intervention: education letter, bookmark, and sticker with stroke symptoms and EMS contact number		+	+	+			+
Schmidt et al,[34] Germany	Community education: print media in health care facilities and local amenities, emergency number advertized on public transportation, postal stamps, stroke emergency slogan displayed on ambulances		+	+	+			+

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Sun et al,[26] People's Republic of China	Community education: television, radio, print media, community stroke screening	+					
	Professional education: hospital and paramedic education and benchmarking		+				
Wojner-Alexandrov et al,[29] USA	Community education: PSA, radio, television, and newspaper interviews, door-to-door distribution of leaflets, stickers, and posters			+	+	+	+
	Professional education: educational lectures for prehospital staff and community physicians, selected staff as first responders			+	+	+	+

Abbreviations: PSA, public service announcement; Q&A, question and answer; GP, general practitioner; EMS, emergency medical services.

Uncontrolled before and after studies

A US study by Alberts et al[27] conducted in 1994 reported a statistically significant linear reduction in time to arrival over the course of the study, from 3.2 hours to 1.5 hours. However, the authors caution that although the percentage of patients arriving early increased, the time from stroke onset to first medical contact did not, suggesting that the delay reduction might be attributed to faster paramedic response. A German study conducted in 1995 by Müffelmann et al[31] reported an overall statistically significant reduction in time to presentation from 8 hours to 5 hours. A study by Luiz et al,[30] also conducted in Germany, reported a 62% reduction in median delay time following intervention, from 368 minutes to 140 minutes. Another US study by Wojner-Alexandrov et al[29] reported no significant decrease in delay in the active intervention phase; however, there was a significant difference in patients presenting <120 minutes in the active intervention phase as compared with the preintervention data. A final US study by Hodgson et al[28] examined time to presentation in categories of less than 5 hours and less than 2.5 hours. A statistically significant increase in both categories was reported following the intervention; however, the magnitude of effect was small in both instances.

Prospective observational studies

One US study by Barsan et al[35] was conducted in 1992 before routine thrombolysis administration; thus, despite the reported effect of increased presentations under 24 hours from 40% to 85%, the intervention encouraged treatment within 8 hours and examined presentation within 24 hours of symptom onset as a behavioral outcome. Therefore, early presentation within the current thrombolytic treatment window was not examined. A study in Germany by Schmidt et al[34] reported a decrease in median delay from 12 to 3.2 hours. This decrease was statistically nonsignificant in the small sample studied; however, it had clinical significance as the largest reported reduction in OTD time of approximately 9 hours.

Retrospective observational study

The retrospective UK study by Addo et al[33] analyzing stroke events over 10 years examined the change in the proportion of patients who delayed pre and post a year-long intervention with the FAST campaign and reported no change in the proportion of patients arriving within 3 hours or a decrease in prehospital delay as a result of a public stroke awareness campaign.

Increase in thrombolysis rates

Eight studies examined thrombolysis rates as a behavioral outcome measure, with only three studies reporting a statistically significant increase in thrombolysis rates following a public educational intervention.

Interestingly, the RCT[21] reported no significant difference in thrombolysis rates between the intervention and control groups. The time series analysis by Flynn et al[22] analyzed data from the Safe Implementation of Thrombolysis in Stroke UK database, which included data from 27 hospital sites across England. Findings showed an overall increase in thrombolysis rates over the study period, with specific increases observed following waves 1 and 3 of the FAST campaign. The controlled before and after study by Moregenstern et al[24] reported a statistically significant increase in thrombolysis rates from 2.21% to 8.65% for ischemic stroke in the intervention community following an educational intervention, with no change observed in the control community. A follow-up study[36] within this population reported a sustained increase in thrombolysis rates (11.2%) in the intervention community at 6 months postintervention. The controlled before and after study by Sun et al[26] reported a 4.8% increase in thrombolysis rates in the intervention community following a community-based intervention. An uncontrolled before and after study by Wojner-Alexandrov et al[29] examined the change in thrombolysis rates in nine treatment centers from the preintervention to the active intervention phase. No consistent trend was observed over the intervention phase, although four hospitals reported a rise in thrombolysis (only one of these being a statistically significant rise), while two hospitals in this cohort reported decreased thrombolysis rates. Another uncontrolled before and after study by Müffelmann et al[31] reported an increase in thrombolysis cases, from one case to nine cases, following a public education campaign. The prospective study by Schmidt et al[34] reported an overall increase in thrombolysis rates but did not provide statistical analysis of the reported change. The retrospective study by Addo et al[33] reported no significant difference in thrombolysis rates before or after a public stroke awareness campaign.

Activation of ambulance transport

Ambulance transports for stroke were outcome measures in five studies, with four reporting statistically significant increases in ambulance transportations for stroke following an educational intervention. The controlled study by Chen et al[25] reported that the percentage of patients calling EMS increased per year from 2008, with a 10.8% overall increase noted and an increased proportion evident in the intervention community in 2010. The study by Bray et al[32] examined the impact of a multimedia educational intervention on the proportional increase in ambulance dispatches over a 10-year period. The authors reported a yearly significant increase in ambulance dispatches in the month after the annual stroke awareness week from 2007 once the message to call an ambulance in response to stroke was added to the existing media message. The study by Wojner-Alexandrov et al[29] reported a significant increase in paramedic transports for stroke during the intervention phase as compared with the preintervention phase. The retrospective study by Luiz et al[30] reported a 4.5% increase in EMS transports for stroke postintervention. The same study also examined the time taken from symptom onset to EMS activation (ie, calling the EMS telephone number) and found a significant reduction of 79% in median activation time to 54 minutes.

ED presentations

Three studies examined ED presentations with stroke as an outcome measure, with all studies reporting some statistically significant effects, with increases in ED presentations for stroke observed. One before and after study by Hodgson et al[28] examined ED presentations with stroke symptoms and reported a mean increase in ED presentations over the study period. The authors reported that exposure to the mass media campaign accounted for 9% of the total variance in ED admissions for stroke, 15% of the variance for presentations under 5 hours, and 5% of the variance for presentations within 2.5 hours. The UK time series analysis by Flynn et al[22] of all ED activity for England from May 2007 to February 2011[22] revealed that there was a general increase in ED presentations over the study period. However, when ED trends immediately following the FAST campaign were examined, only the time period following wave 1 of the FAST campaign evidenced a significant increase. The second time series analysis by Mellon et al[23] reported similar findings to the UK analyses. The Irish data examined ED presentations with stroke symptoms over a 12-month period, with significant increases in ED presentations only observed following wave 1 of the FAST campaign.

Mortality

The RCT[21] examined the percentage of deaths during hospital stay between the intervention and control groups, reporting no statistical difference in mortality between the groups. A controlled before and after study by Sun et al[26] reported no difference in the 90-day fatality rate between the intervention and control groups; however, interestingly, the intervention

group had significantly higher functional outcome scores, measured on the Barthel Index, than the control group at 90 days poststroke.

Discussion

This review examined the effectiveness of public interventions aimed at reducing patient prehospital delay in acute ischemic stroke. Outcomes of interest were focused on patient behavior (patient delay, EMS use, and ED presentation) or measurable consequences of behavior (thrombolysis rates and mortality). The findings suggest that educational interventions aimed at the public have some positive effects on reducing patient delay to hospital presentation and other behavioral indicants such as ambulance use, ED presentation with suspected stroke, and thrombolysis rates. However, results must be interpreted with caution, as large heterogeneity was evident between study designs and methodology.

Interventions such as multimedia campaigns have demonstrated efficacy in increasing stroke knowledge and awareness and the intention to respond to stroke as an emergency.[37–39] However, bridging the gap between behavioral intention and behavior itself remains a challenge in acute stroke care and has similarly been identified as a key challenge in other health contexts, such as acute myocardial infarction.[40] The intervention in this review that evidenced the largest and, more crucially, more sustained behavioral change in thrombolysis rates involved a scientifically based, multifaceted behavioral intervention that was developed from focus groups with stroke survivors in order to identify themes and issues that contribute to delay.[24] The theory-based strategy involved role-modeling of response to stroke by promoting community figures who were stroke survivors and demonstrated that immediate response to stroke symptoms results in a better outcome. Furthermore, this type of intervention did more than just demonstrate signs and symptoms to the public; it outlined the time-dependent nature of successful treatments for ischemic stroke, which highlights this strategy as a possible key component in interventions to reduce delay in presentation with stroke symptoms.

The intervention in the RCT study[21] did not have an observable impact on delay behavior. This finding has been similarly reported in RCT studies examining the effect of interventions to reduce delay in presentation with symptoms of an acute myocardial infarction. Stroke researchers can potentially learn from the more established acute myocardial infarction literature in order to improve treatment outcomes for acute ischemic stroke. Both conditions are life-threatening events with acute onset and similar mechanism of infarction. Successful treatment involves revascularization, and hence both have similar need for time-dependent intervention. A large randomized clinical trial[41] to reduce prehospital delay in acute coronary syndrome (n=5,322) found that a one-to-one educational and counseling intervention with patients with documented heart disease at 2-year follow-up resulted in no change to prehospital delay times, although the experimental group was more likely to call emergency services and self-medicate with aspirin following symptom onset. Secondary analysis of this cohort[42] aimed to characterize the patients who best responded to the intervention, in order to understand the mechanisms by which interventions work. It was found that decreasing anxiety was associated with prehospital delay reduction, and authors suggest that tailoring interventions to target psychosocial and emotional responses to acute onset of symptoms may be more effective than addressing knowledge, attitudes, or intention. Methods such as community role-modeling of stroke survivors may be useful in reducing potential anxiety and removing potential psychosocial barriers to timely acute stroke care.

Seven studies in this review that reported significant effects described interventions that targeted both professional and public behavior. Professional education may have contributed to improved thrombolysis rates through improved prehospital paramedic response and in-hospital systemic delay reductions. This interaction effect was not examined in any study presented here, and it is therefore difficult to draw conclusions on which element (public or professional) was most effective. Patient recognition and action in the wake of stroke symptom onset is the first step in the symptom delay trajectory, and the studies included in this review focused on public interventions that targeted this step in the onset to treatment delay trajectory. The next two stages, from initiation of medical contact to hospital arrival, and from arrival to treatment, are out of the patient's control and rely on prompt professional action to reduce delays to treatment. Significant advances in prehospital management of stroke by paramedic protocols and EMS systems, coupled with in-hospital improvements in the management of stoke, have translated into shorter overall onset to treatment times. For example, a recent single-center study[43] reported a door-to-needle time of 20 minutes, which was attributed to concurrent in-hospital systemic changes and the employment of a prehospital notification system, which resulted in a smoother transition from prehospital to in-hospital emergency care. A multicenter intervention[44] also reported a clinically significant increase in thrombolysis use in the target population following a

multicomponent intervention, although this increase was not statistically significant. A shorter door-to-needle time affords the stroke patient slightly more time to recognize and respond accordingly to stroke symptoms without risk of missing the thrombolysis treatment window. The findings from the time series analyses included in this review provide further evidence for this gradual improvement in pre and in-hospital acute management of stroke. Flynn et al[22] highlight that in the study period from 2007 to 2011, there were significant increases in ED presentations for stroke, coupled with a decline in time-consuming general practitioner-referred stroke cases, and an increase in thrombolysis rates over time. These service improvements occurred in parallel with improvements in patient response attributable to the FAST campaign. Changing the public perception of acute stroke is a challenging and lengthy process involving large, heterogeneous populations. Perhaps a sustainable reduction in onset-to-needle time may be best achieved over a shorter time frame by improving in-hospital acute stroke care, as in-hospital interventions have the advantage of focusing on a single network or organization in a controlled environment, such as the ED or EMS network.

This review had some limitations. The heterogeneity of the included studies limited the comparability of the interventions, and critical appraisal of the included studies revealed that potential bias or confounders were not successfully addressed in the majority of studies. Only one RCT was identified, and therefore methodological deficiencies of included studies limit the weight that can be given to the demonstrated effects. Some of the included studies also retrospectively examined intervention effects as a secondary analysis to a larger study, which again decreases the methodological rigor. Studies in this area should utilize, at a minimum, a controlled before and after design or interrupted time series design if an RCT design is not feasible,[42] in order to associate any observed changes with the specified intervention.

Conclusions

In conclusion, this review found that interventions to educate the public on the correct response to stroke symptoms evidenced varying degrees of success, with most interventions successful in initiating correct public responses when stroke occurred. Studies that were particularly successful in achieving reductions in prehospital delay adopted a combined multilevel approach to education, incorporating mass media, targeted community education, and professional education. Sustained reduction in patient delay and increased thrombolysis administration were achieved by an intervention that specifically promoted the use of thrombolysis for stroke and its associated benefits. There is a need for well-designed research trials with clearly described intervention components to provide evidence for the effectiveness of interventions to reduce delayed presentation with stroke symptoms.

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Disclosure

The authors report no conflicts of interest in this work.

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