

Impact of a Mobile Tool on Stroke Code Time Documentation: The VICTUS Study

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Abstract

Introduction: Time tracking of acute stroke assistance is crucial for treatment goals. Resources availability varies among stroke centers. We aim to assess a low-cost mobile app's impact on collecting stroke assistance times in a traditional hospital.

Patients and Methods: Neurology consultants and residents tested the application prototype voluntarily from July 14 to September 30, 2021. A prospective observational study, based on pre- and post-implementation anonymous satisfaction surveys, was designed. While the primary objective was not data comparison, the stroke assistance time data were collected and compared with 2019 same months.

Results: The majority of volunteers (9/12) actively used the application. Most of them (88.8%) were satisfied both in terms of using the app and their confidence in registering patients. All users found it to be user-friendly and a valuable tool for data-driven decision making allowing an effortless data storage. The app notably decreases their perception of inaccurate or lost data and increases their motivation to record and improve stroke assistance times. Data collection process was standardized. Treated patients accounted for only 31% of total stroke phone calls (16/52). The median door-to-needle time was 20 minutes, IQR 12.5-26 minutes, showing a 16.6% relative reduction compared to the previous same period.

Discussion and conclusions: An easy-to-use time-tracking app can boost team motivation, streamline stroke care evaluation, and potentially improve response times. However, more research is needed for a comprehensive assessment.

Keywords: *Storage and Retrieval; Mobile Applications; Stroke; Time Management; Time-to-Treatment; User-centered design.*

Introduction

Stroke is a highly relevant pathology within the healthcare system due to its high incidence, morbidity, mortality, and economic burden. In Spain, a stroke occurs every six minutes, making it the second leading cause of death overall, the primary cause among women, and the third among men [1]. Furthermore, stroke stands as a leading cause of long-term disability in adults [2].

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Of all cerebrovascular cases in our country, approximately 81% are attributed to ischemic strokes [3]. Research consistently shows that administering reperfusion therapy earlier significantly improves survival rates and functional outcomes [4-6]. Consequently, optimizing the time to treatment initiation is a crucial goal in acute ischemic stroke care. Establishing and actively monitoring specific timeframes is recommended to enhance performance [7].

The methods for tracking and storing assistance times vary among institutions, with a significant number previously relying on pen and paper approaches. The manual data entry process is time-consuming and prone to human error, complicating the ability to make timely decisions and often relying on non-updated or inconsistent data. While the impact on specialists' work and data accuracy has not been a primary concern, the advent of digitalization introduces new possibilities. In contemporary healthcare, smartphones have become indispensable tools for physicians, enabling fast and easy access to information. Mobile applications have proven useful for various healthcare tasks, including pre- and intra-hospital management of acute stroke. Several studies [8-15] have yielded promising outcomes by effectively reducing the time to treatment initiation, enhancing interdisciplinary coordination, and minimizing data extraction and processing durations. Despite the evident benefits of technology and mobile applications in streamlining healthcare processes, there remains a notable absence of their integration within stroke assistance in Spain. While some regions have adopted digital systems, yet the majority still lack real-time data collection via mobile technology. This gap poses additional challenges when collecting data and sharing it across the different healthcare systems in the country.

A low-cost mobile application prototype, Victus, was developed using a human-centered design approach for the purpose of improving the code stroke times register at Santa Lucía University General Hospital. This study aimed to investigate the benefits of this implementation in a traditional, manually-operated hospital setting.

Methods

Study Design

An observational, prospective, single-center study was designed to evaluate the impact of implementing a new app for recording the assistance times of stroke code patients. Anonymous satisfaction surveys before and after implementation were utilized as the primary data collection method among stroke care professionals who voluntarily adopted the app. Historical data served as a control to assess the new system's repercussion on assistance times.

The study was conducted at Santa Lucía University General Hospital in Cartagena, Spain, a level two hospital that serves around 422,000 inhabitants in our region [16], from July 14 to September 30, 2021. The hospital operates under a drip-and-ship model, providing 24-hour access to specialized acute stroke care and intravenous thrombolysis through an on-site on-call neurologist and a dedicated Stroke Unit.

The subjects of our study were volunteer neurologists and neurology residents who routinely handle stroke code patients at our hospital. They evaluate clinical information provided by the first attending physician over the phone, make decisions regarding code stroke activation, record assistance time data, and provide care to stroke patients upon their arrival.

Volunteer testers collected prospective stroke code data for all consecutive, unselected patients undergoing acute stroke evaluation not including personal patient information.

Being an evaluation process without identifiable patient information or intervention, and based on anonymous qualitative interviews the Research Ethics Committee approval was not required.

The Application

Recognizing the critical importance of time recording in stroke code situations, the primary researchers, CSV and AM, embarked on a product discovery phase and identified the need for a user-friendly and precise solution. This led to the development of a mobile application prototype called Victus App. This product was thoughtfully designed with a human-centered approach, addressing the unique needs and challenges faced by on-call neurologists at Santa Lucía University General Hospital and effectively addressing the pain points discovered within the user flows in stroke code situations.

The Victus App was developed using the versatile no-code application development platform, AppSheet, which is HIPAA compliant and compatible with Desktop, iOS and Android devices. AppSheet harnesses the capabilities of Google Cloud and Google Workspace, enabling us to instantly record stroke code data from the app into a Google Cloud spreadsheet. To safeguard patient privacy, no identifiable patient information was included.

The VICTUS App had several key features that allowed users to:

- 1) Label Onset Activation type: unknown, wake up, known onset.
- 2) Categorize Stroke Activation as in- or extra-hospital case,
- 3) Log times in a frictionless way by a single touch of a button for each step: Onset time, Call time, Arrival time, CT time and Needle time.
- 4) Collaborate on the same case through multiple devices.
- 5) Gain visibility of registered times enhancing alertness.
- 6) Record Treatment Decisions including whether deactivation or which reperfusion treatments were administered.
- 7) Synch Data instantly with a cloud database for efficient data management.

A functional prototype, meticulously designed to meet the key criteria set by the primary researchers (compatibility with iOS and Android, user-friendliness, efficient time recording, and easy data export and reporting), underwent thorough testing and was improved in an iterative way taking into account user feedback.

Outcome measure and data analysis

Descriptive analysis was performed on the results, including frequency distributions and proportions for categorical data, and median values with interquartile ranges (IQR) for continuous variables.

1. The primary aim was to evaluate the impact of the app on stroke assistance time records.

Satisfaction surveys were conducted through Google Forms before and after the implementation of the Victus app among all study participants. The respondents were informed about the anonymous nature of the survey prior to completion. The principal investigator (CSV) was part of the center's stroke care and also a user of the app but was not involved in the evaluation to ensure an unbiased assessment of the product.

The pre-implementation satisfaction survey was focused on the previous method of logging stroke assistance times in which the care provider would manually note down the details while also taking care of the patients. Subsequently, this data would be transferred into an on-call paper diary, then retrospectively entered into a spreadsheet by a neurology resident.

The post-implementation satisfaction survey focused on the Victus app. Caregivers opened the app on their mobile devices and initiated a new case upon receiving the stroke code call. Some fields were preselected with common information such as known onset stroke to save time. The caregivers recorded assistance times by simply tapping a button during assistance. Finally, they selected the treatment decision from a dropdown menu. Instantly, the time data was automatically transferred to a spreadsheet that was accessible to any team member.

The questionnaire, as outlined in [Table 1](#), comprised four sections containing a total of 27 questions. The majority (19/27) were closed-ended multiple-choice items, using a 6-point scale to measure satisfaction, agreement, or utility (with higher numerical values indicating higher levels). Each scale option included descriptors for clarity, and an intermediate step was omitted to prevent the central tendency effect. Additionally, eight open-ended questions focused on qualitative data collection processes, the completeness and reliability of recorded information, as well as pinpointing pain points.

2. The secondary objective was the effect of the App on stroke assistance times.

We collected door-to-needle time (DTN) data from both our center's historical manual database and the automatic App database. We analyzed the differences in median DTN times between the period of Victus implementation and the corresponding period in 2019. The year 2020 was excluded from the analysis due to the impact of the COVID-19 pandemic on our stroke code protocol.

Table 1. Structure and Content of Questionnaire Sections.

Section	Description	Number of questions
Tracking system description	Gathering information on data collection processes, pros and cons of the system	5
Satisfaction survey	Gauging overall satisfaction with different features of the system	15
Pain points	Evaluating issues like record-keeping accuracy, perceived data loss, and unregistered patients.	3
Utility degree	Assessing areas for improvement and uncovering opportunities	4

Results

Ten attendings and two senior residents agreed to participate in the study. The application was actively used by the majority of volunteers, with nine out of twelve using it regularly. All participants completed both evaluation surveys, but only those who used the app answered the questions related to it. Reasons for non using the app included: no stroke codes were hospitalized during the shift of one of the attendings, while two other participants mentioned the inertia of using the old method as the main challenge in adopting the new behavior.

Upon analysis of responses and the registered times in the databases, it was discovered that users of the classic method logged times in a non-consistent approach and engaged in laborious manual tasks. The introduction of the app standardized data fields, and removed the need for manual transcription, eliminating data inconsistencies and significantly reducing workload. Notably, app users experienced a reduction in inaccurate or unrecorded data from 50% (IQR 26.25%-87.5%) with the classical model to 5% (IQR 2.5%-13.75%) with the VICTUS app.

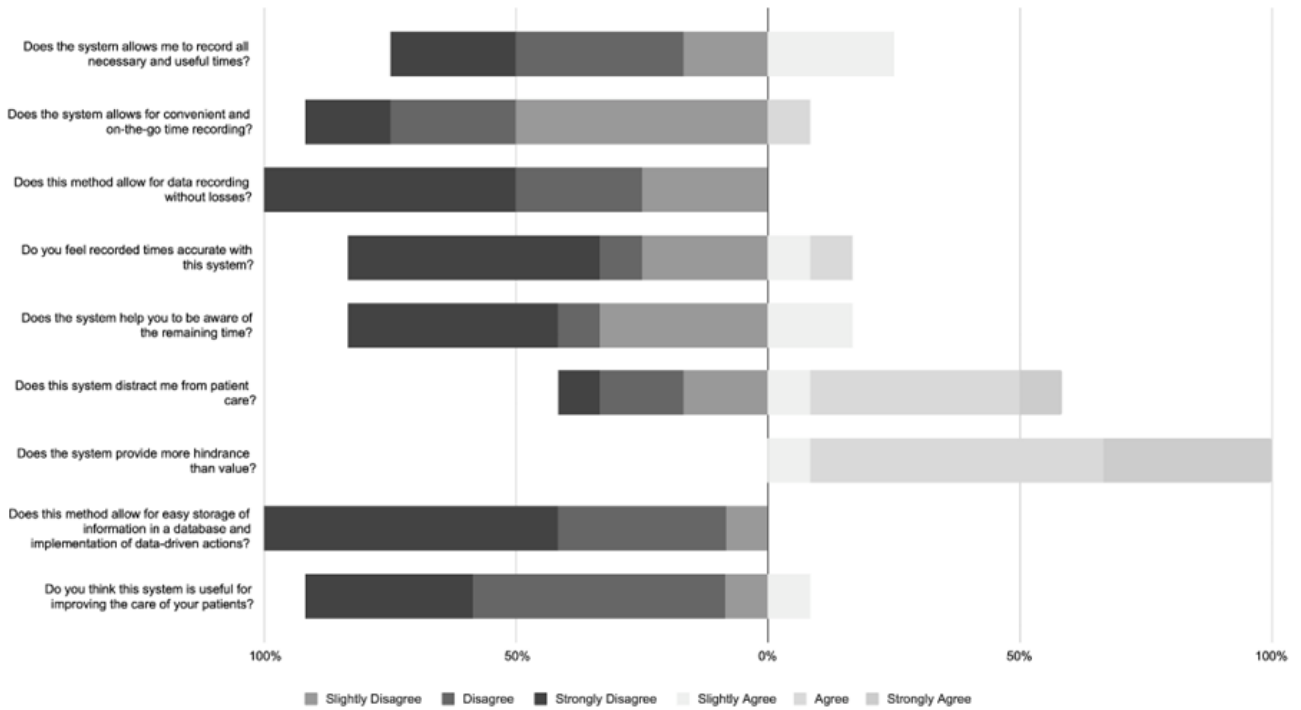
The survey results revealed widespread satisfaction with the VICTUS application (Figure 1). A majority (88.8%) of participants expressed satisfaction with both using the app and their confidence in registering patients. They found it useful for enhancing stroke assistance and expressed a willingness to continue using it.

All users (100%) described the app as user-friendliness, accuracy, and value in facilitating data-driven decision-making through effortless data storage. Furthermore, the app significantly boosts their motivation to record and improve stroke assistance times while they perceive it as more beneficial than burden, and enabling the minimization of data loss.

A total of 52 stroke phone calls were registered during the study period, which spanned 63 days with users actively using the app. Only 31% (16/52) from all the events evaluated met the criteria to receive any reperfusion treatment.

The median door-to-needle time for the 12 extra-hospital activation thrombolysed patients was 20 minutes, IQR 12.5-26 minutes, being 100% (12/12) within 60 min and 91.6% (11/12) within 45 min. This median DTN time showed a 16.6% relative reduction compared to the 2019 same period when 15 extra-hospital stroke patients were thrombolysed in a median of 24 minutes, IQR 17-38 minutes, 93% (14/15) being thrombolysed within 60 min and 86.6% (13/15) within 45 min.

Agreement levels in survey reference to manual method.



Agreement levels in survey reference to VICTUS App.

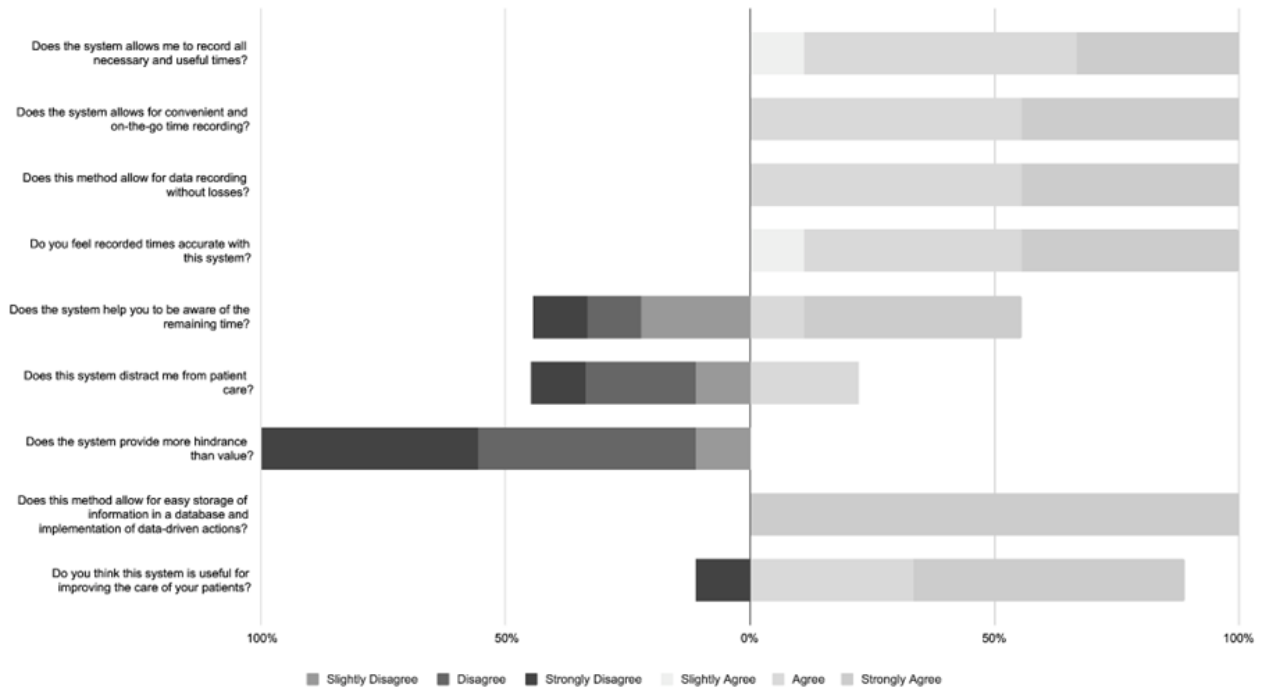


Figure 1. Summary of Responses to Representative Questions from Pre- and Post-Implementation Satisfaction Surveys.

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Discussion

In acute stroke care, timely decision-making is crucial. Documenting attendance times during care aids future improvements but can be burdensome for stroke providers. Simplifying this process would facilitate adherence to time tracking, enabling ongoing improvement efforts. The VICTUS App was designed to streamline time recording by adapting the process to the user, enabling quick recording with a single tap on the smartphone. Numerous articles have explored the utilization of applications in acute stroke management, with some incorporating time tracking features, albeit not as the primary focus of analysis [9-15]. Through an assessment of this system's impact on neurologists' satisfaction, our study aims to offer valuable insights associated with mobile technology in the stroke code process.

The digital stroke time tracker not only accurately captured and quantified the necessary time intervals but also addressed the challenges associated with conventional documentation within our institution. It provided an effective solution that enhanced accuracy and efficiency in documentation. The standardization of recorded times, reduced errors, and improved data accessibility enabling ongoing improvement cycles highlight the significant impact of such mobile tools on enhancing stroke care processes. Also, the automated data storage system enables to easily share updated data with other Stroke care centers, facilitating broader studies and collaboration. Furthermore, both frictionless register and automated data storage help physicians save time. This allows them to focus on core patient tasks during the assistance stroke code. Consequently, users' satisfaction was high, with a majority expressing a desire to continue using it.

In line with previous findings [10-15], we noted a reduction in DTN time after implementation, showing that the app does not hinder the process. The enhanced motivation stemming from having a frictionless way to log times and heightened awareness of time could be contributing factors to this improvement. While other studies have shown greater decreases in DTN (between 12.8 minutes to 40 minutes) [10-15], it is worth noting that these centers had longer median DTN times pre-implementation compared to our hospital. Our adherence to the Helsinki model [17] had already optimized our stroke code treatment times, providing a competitive baseline. As a result, further improvements may be challenging to achieve. However, we approach these reductions cautiously, considering the relatively small number of cases and the fact that the study was not primarily designed to demonstrate reductions in DTN times.

This application serves as an example of how technology that is designed with a user-centered approach, can motivate users, reduce burden, and improve stroke care processes. In the future, additional features could be scoped based on their utility and effectiveness. These may include functionalities such as sharing assistance times in regional or national databases and enabling the customization of timestamps for evaluation could be explored. These new features could aid in identifying bottlenecks and implementing new recommendations to further enhance the stroke care process.

Limitations of our study should be acknowledged. Its observational design restricts the level of evidence provided. The small cohort of volunteers, in a single hospital setting, may limit the generalization of our findings. Further research is needed to assess the reproducibility of the tool across various healthcare centers. Additionally, the voluntary nature of participation may introduce selection bias. Regarding researcher affiliation, while one researcher involved in app development has a neurology department affiliation, she was excluded from survey participation, thereby mitigating potential bias.

Conclusion

The implementation of VICTUS, a low-cost, user-centered designed app for stroke time-tracking, effectively replaces traditional registries without burden. The impact of this tool on neurology on-call work has been satisfactory; it appears to boost team motivation for stroke documentation and improve efficiency, accuracy, and easy access to assistance data storage. Moreover, it holds the potential to enhance reperfusion times, though further study is necessary to confirm this. Overall, VICTUS demonstrates significant promise in fostering a culture of continuous improvement in stroke care delivery.

Conflict of Interests and Disclosures

The authors declare no conflict of interest. Partial findings were showcased at a regional scientific conference in line with the awarded scholarship.

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References

1. Instituto Nacional de Estadística. Defunciones según la causa de muerte del año 2018. Published December 19, 2019. Accessed December 20, 2024. https://www.ine.es/prensa/edcm_2018.pdf.
2. GBD 2019 Stroke Collaborators. Global, regional, and national burden of stroke and its risk factors, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet Neurol.* 2021;20(10):795-820. [https://doi.org/10.1016/S1474-4422\(21\)00252-0](https://doi.org/10.1016/S1474-4422(21)00252-0).
3. Díaz-Guzmán J, Egido JA, Gabriel-Sánchez R, Barberá-Comes G, Fuentes-Gimeno B, Fernández-Pérez C, on behalf of the IBERICTUS Study Investigators of the Stroke Project of the Spanish Cerebrovascular Diseases Study Group. Stroke and Transient Ischemic Attack Incidence Rate in Spain: The IBERICTUS Study. *Cerebrovasc Dis.* 2012;34(4):272-81. <https://doi.org/10.1159/000342652>.
4. Hacke W, Donnan G, Fieschi C, Kaste M, von Kummer R, Broderick JP, Brott T, Frankel M, Grotta JC, Haley EC Jr, Kwiatkowski T, Levine SR, Lewandowski C, Lu M, Lyden P, Marler JR, Patel S, Tilley BC, Albers G, Bluhmki E, Wilhelm M, Hamilton S; The ATLANTIS, ECASS, and NINDS rt-PA Study Group Investigators. Association of outcome with early stroke treatment: pooled analysis of ATLANTIS, ECASS, and NINDS rt-PA stroke trials. *Lancet.* 2004;363(9411):768-74. [https://doi.org/10.1016/S0140-6736\(04\)15692-4](https://doi.org/10.1016/S0140-6736(04)15692-4).
5. Lees KR, Bluhmki E, von Kummer R, Brott TG, Toni D, Grotta JC, Albers GW, Kaste M, Marler JR, Hamilton SA, Tilley BC, Davis SM, Donnan GA, Hacke W; for the ECASS, ATLANTIS, NINDS and EPITHET rt-PA Study Group Investigators. Time to treatment with intravenous alteplase and outcome in stroke: an updated pooled analysis of ECASS, ATLANTIS, NINDS, and EPITHET trials. *Lancet.* 2010;375(9727):1695-703. [https://doi.org/10.1016/S0140-6736\(10\)60491-6](https://doi.org/10.1016/S0140-6736(10)60491-6).
6. Fonarow GC, Smith EE, Saver JL, Reeves MJ, Bhatt DL, Grau-Sepulveda MV, Olson DM, Hernandez AF, Peterson ED, Schwamm LH. Timeliness of tissue-type plasminogen activator therapy in acute ischemic stroke: patient characteristics, hospital factors, and outcomes associated with door-to-needle times within 60 minutes. *Circulation.* 2011;123(7):750-8. <https://doi.org/10.1161/CIRCULATIONAHA.110.974675>.
7. Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, Biller J, Brown M, Demaerschalk BM, Hoh B, Jauch EC, Kidwell CS, Leslie-Mazwi TM, Ovbiagele B, Scott PA, Sheth KN, Southerland AM, Summers DV, Tirschwell DL. Guidelines for the Early Management of Patients With Acute Ischemic Stroke: 2019 Update to the 2018 Guidelines for the Early Management of Acute Ischemic Stroke: A Guideline for Healthcare Professionals From the American Heart Association/American Stroke Association. *Stroke.* 2019;50(12):e344-e418. <https://doi.org/10.1161/STR.0000000000000211>.

8. Nogueira RG, Silva GS, Lima FO, Yeh YC, Fleming C, Branco D, Yancey AH, Ratcliff JJ, Wages RK, Doss E, Bouslama M, Grossberg JA, Haussen DC, Sakano T, Frankel MR. The FAST-ED App: A Smartphone Platform for the Field Triage of Patients With Stroke. *Stroke*. 2017;48(5):1278-84. <https://doi.org/10.1161/STROKEAHA.116.016026>.
9. Munich SA, Tan LA, Nogueira DM, Keigher KM, Chen M, Crowley RW, Connors JJ, Lopes DK. Mobile Real-time Tracking of Acute Stroke Patients and Instant, Secure Inter-team Communication - the Join App. *Neurointervention*. 2017;12(2):69-76. <https://doi.org/10.5469/neuroint.2017.12.2.69>.
10. Martins SCO, Weiss G, Almeida AG, Brondani R, Carbonera LA, de Souza AC, Martins MCO, Nasi G, Nasi LA, Batista C, Sousa FB, Rockenbach MABC, Gonçalves FM, Vedolin LM, Nogueira RG. Validation of a Smartphone Application in the Evaluation and Treatment of Acute Stroke in a Comprehensive Stroke Center. *Stroke*. 2020;51(1):240-246. <https://doi.org/10.1161/STROKEAHA.119.026727>.
11. Dickson R, Nedelcut A, McPeck Nedelcut M. Stop Stroke: a brief report on door-to-needle times and performance after Implementing an acute care coordination medical application and implications to Emergency Medical Services. *Prehosp Disaster Med*. 2017;32(3): 343-347. <https://doi.org/10.1017/S1049023X17000097>.
12. Dickson RL, Sumathipala D, Reeves J. Stop Stroke© Acute Care Coordination Medical Application: A Brief Report on Postimplementation Performance at a Primary Stroke Center. *J Stroke Cerebrovasc Dis*. 2016;25(5):1275-9. <https://doi.org/10.1016/j.jstrokecerebrovasdis.2015.12.001>.
13. Andrew BY, Stack CM, Yang JP, Dodds JA. mStroke: "Mobile Stroke"-Improving Acute Stroke Care with Smartphone Technology. *J Stroke Cerebrovasc Dis*. 2017;26(7):1449-56. <https://doi.org/10.1016/j.jstrokecerebrovasdis.2017.03.016>.
14. Rubin MN, Fugate JE, Barrett KM, Rabinstein AA, Flemming KD. An acute stroke evaluation app: a practice improvement project. *Neurohospitalist*. 2015;5(2):63-9. <https://doi.org/10.1177/1941874414564982>.
15. Noone ML, Moideen F, Krishna RB, Pradeep Kumar VG, Karadan U, Chellenton J, Salam KA. Mobile App Based Strategy Improves Door-to-Needle Time in the Treatment of Acute Ischemic Stroke. *J Stroke Cerebrovasc Dis*. 2020;29(12):105319. <https://doi.org/10.1016/j.jstrokecerebrovasdis.2020.105319>.
16. Servicio de Planificación y Financiación Sanitaria. Servicio Murciano de Salud. Población por AS y ZS según padrón de habitantes. Evolución. Published 2021. Accessed April 25, 2021. <https://www.murciasalud.es/archivo.php?id=154670>.
17. Meretoja A, Strbian D, Mustanoja S, Tatlisumak T, Lindsberg PJ, Kaste M. Reducing in-hospital delay to 20 minutes in stroke thrombolysis. *Neurology*. 2012;79(4):306-13. <https://doi.org/10.1212/WNL.0b013e31825d6011>.

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