Accepted: 22 August 2017

DOI: 10.1111/ane.12832

REVIEW ARTICLE

WILEY Acta Neurologica Scandinavica

Role of mHealth in overcoming the occurrence of post-stroke depression

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Funding information
JJM acknowledges receiving current and past support from the Consejo Nacional de Ciencia, Tecnología e Innovación Tecnológica (CONCYTEC), DFID/MRC/Wellcome Global Health Trials (MR/M007405/1), Fogarty International Center (R21TW009982), Grand Challenges Canada (0335-04), International Development Research Center Canada (106887, 108167), Inter-American Institute for Global Change Research (IAI CRN3036), National Heart, Lung and Blood Institute (5U01HL114180, HHSN268200900028C), National Institute of Mental Health (1U19MH098780), Swiss National Science Foundation (40P740-160366), Universidad Peruana Cayetano Heredia, and the Wellcome Trust (074833/Z/04/A, WT093541AIA, 103994/Z/14/Z). Dr Ovbiagele is supported by National Institutes of Neurological Disorders and Stroke (R21NS094033).

Depression associated with stroke affects roughly one-third of stroke survivors. Post-stroke depression (PSD) is thought to adversely influence functional outcome by limiting participation in rehabilitation, decreasing physical, social, and cognitive function, and affecting neuroplasticity thereby placing stroke survivors at high risk for future vascular events. PSD has also been associated with higher mortality rates after stroke. In Peru, a country where there is no national stroke program and mental health disorders are largely underdiagnosed and untreated, people with PSD are likely to be further challenged by dependency and impoverished conditions that will limit their use of ambulatory services, leading to inadequate clinical follow-up. In this scenario, mobile health (mHealth) technology offers a promising approach to extend access to high-quality and culturally tailored evidence-based psychological care to address PSD given that cell phone use, Internet connectivity, and digital health technology have met a rapid growth in the last years and thus contribute to the attainment of broader Sustainable Development Goals (SDGs). The limited evidence of the effectiveness of mHealth for PSD calls for researchers to fill a knowledge gap where Peru poses as an ideal setting because rapid expansion of digital technology and current mental health-care reform could be leveraged to enhance post-stroke outcomes. This article proposes the rationale for a suitable evidence-driven, mHealth-based, PSD self-management intervention called iMOODS—Investigating the role of mHealth in overcoming occurrence of depression after stroke—that could be tested among recent stroke patients with PSD in resource constrained settings.

KEYWORDS
depression, implementation, mHealth, stroke

1 | INTRODUCTION

1.1 | Burden of stroke

The Sustainable Development Goals (SDGs) represent the main global concerns proposed by world leaders to be solved by 2030. Among their specific targets, to strengthen capacities in low-and middle-income countries (LMIC) for risk reduction of global health risks is a major concern.[1] In that context, stroke, a major cardiovascular disease, merits attention.

Globally, stroke affects >60 million people and the overwhelming majority of them live in low-and middle-income countries LMIC,[2-4] thereby exacting tremendous societal and economic tolls.[5] Moreover, while stroke mortality rates have dropped modestly due to better medical treatments, the number of individuals living with the residual effects of stroke worldwide is rising.[6] Roughly, 75% of patients survive a first stroke, and of these patients, 25% are left with a minor disability and 40% experience moderate-to-severe disabilities.[7] Beyond the lingering physical, psychological, and social effects of a first stroke, up

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to 25% of stroke survivors have recurrent strokes,[8] and the morbidity and mortality after a recurrent stroke is worse than that of a primary stroke, with a near doubling of the 30-day fatality rate after a first recurrent stroke vs a first-ever stroke.[9]

In Latin America, stroke is the fourth leading cause of years of life lost (YLL).[10] In Peru, stroke is the fifth leading cause of YLL,[10] and stroke is proportionally responsible for even greater rates of disability and death, than in high-income countries like the USA.[11,12] While there is no national stroke program for stroke in Peru,[13] stroke is listed as a leading cause of disease burden for national priority setting purposes.[14]

1.2 | Post-stroke depression (PSD)

Stroke is strongly linked to the three dreaded "Ds": disability, death, and dementia.[15] However, mounting evidence shows that stroke is linked to another dreaded "D," depression. Depression roughly affects one-third of stroke survivors with a cumulative incidence of 55%.[16,17] Post-stroke depression (PSD) adversely affects stroke recovery by limiting participation in rehabilitation, decreasing physical, social, and cognitive function, and compromising the biologic process of neuroplasticity.[18–20] Further, PSD increases the risk of dying after a first stroke, and experiencing recurrent strokes, presumably due to the decreased motivation associated with PSD, leading to lesser patient willingness to adhere to preventive therapies.[21-23]

In Peru, PSD has been poorly addressed, and very few published studies have explored the relationship between depressive symptoms and stroke. A study from 2006 at a public hospital setting in Lima, Peru's capital, found that 67% of 180 stroke patients suffered from depression at 1 year after the index stroke.[24] Another study, published in 2009, reported that the prevalence of stroke was 24% higher among people who had depressive episodes compared to those without it.[25] Finally, in 2011 and among stroke patients, severe disability and dependence was found to be 40% higher among stroke survivors suffering with depression in comparison with those without depression.[26]

1.3 | Challenges with stroke and mental healthcare in LMIC

Most healthcare systems are acute care-oriented, specialist-centered, urban-located, and fragmented and are thus ill-prepared to deal with chronic conditions, especially in LMIC.[27,28] For patients in these poorly resourced regions, optimal care is far below evidence-based standards, and to rely on the relatively few overwhelmed specialists alone to provide such services is not only unrealistic, but also unsustainable.[29] A similar situation characterizes mental health services in most LMIC, where rates of depression and anxiety reach almost 70%,[30] there is a shortage and inefficient distribution of professionals,[31] and evidence-based treatments are usually not available or accessible for low-income populations. In this context, an innovative strategy to overcome the health system's limitations in stroke and mental health care is needed.

2 | EVIDENCE-BASED MANAGEMENT OF PSD

Evidence suggests that pharmacological treatments may reduce depression symptoms among PSD patients.[32,33] However, it can also increase the risk of adverse events, which means its use as a treatment option should be carefully monitored.[33] In addition, there are limitations in access to pharmacological treatments due to a paucity of financial and human resources for mental health in an LMIC setting like Peru, where there is a ratio of 0.57 psychiatrists per 100 000 inhabitants.[34]

In contrast, psychological interventions are a promising treatment option for PSD.[35] Among them, cognitive behavioral therapy (CBT) has shown positive results in reducing depressive symptoms in patients with PSD.[36] CBT presents an alternative worth exploring[37] as it addresses the particular needs of these patients through a focus on problem-solving approach and skills enhancing.[38] CBT is one of the most effective and economic psychotherapies in general populations,[39,40] including older adults,[41-43] who are at higher risk of depression after stroke.[44] Moreover, Internet-delivered CBT has shown promising given the current technological advance in the world.[45] Currently, several CBT programs have been assessed with positive results in the management of depression and anxiety.[46,47] It has also been reported that minorities, often underserved, are more engaged to this programs, and thus achieve better results.[48] However, it is of note that delivery CBT for depression through virtual environments has dealt with several barriers such as important dropout rates.[49,50] This is important as a meta-analysis reported a number needed to treat of eight for Internet delivery CBT to have a reduction of 50% in depressive symptoms.[39]

In that scenario, a fair solution will be to implement CBT with other strategies that have proven to be effective for patients with stroke or patients with depression, which combined may be helpful for PSD. For instance, evidence supports the introduction of self-help interventions to mental health treatment.[51] In the case of patients with stroke, preliminary data on self-management interventions indicate an improvement in quality of life, confidence in recovery, and disability outcomes.[52] Support groups are also beneficial in reducing depression in other populations, such as women with breast cancer[53,54] and dementia caregivers.[55] For patients with stroke, there is evidence that participation in these groups may help increase physical functionality and improve recovery.[56]

3 | TECHONOLOGY AS AN OPPORTUNITY

3.1 | Using mHealth to address mental health disorders

A 10-fold increase in cell phone use, Internet connectivity, and digital health technology in LMIC in the last 10 years presents an opportunity for improvements in healthcare delivery and population-based outcomes.[57] The use of mobile phones and Internet creates an opportunity to overcome large distances and mobility limitations, opening new communication channels between patients and providers.[51,58–60]

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In recent years, use of mHealth to address health problems has risen, including its applications for mental health[61-63] and chronic diseases.[64-66] For patients with stroke, mHealth has helped patients follow a rehabilitation program, receive support via phone calls, and monitor the recovery process, all effectively improving physical function.[67-69] Other applications for mHealth involve use of video calls between the patients and therapists, which help reduce the number of therapist visits needed to achieve significant recovery outcomes, in comparison with standard care.[70]

In mental health, text messages have shown a positive impact on medication adherence, appointment attendance, symptom monitoring, and overall satisfaction with health services.[62] Such messages typically consist of providing support, reminders, and information. Likewise, there is evidence that mHealth interventions for depression and anxiety are an effective approach to provide mental health care, particularly for patients who otherwise would not receive any treatment.[61,63,71] Use of applications (apps) for depression treatment has also seen a rise in availability and use, with CBT being one of the most used models for its development.[61,63] However, there is still limited evidence of the effectiveness of using these apps, as well as limited evidence of its use for PSD, which calls for researchers to fill this knowledge gap.[72]

3.2 | Status of mHealth studies in stroke patients

In high-income countries, mHealth apps with educational content on stroke symptoms have been used to assist the lay public and care providers to recognize stroke, facilitate emergency responses, and enhance risk assessment for prompt recognition and management of stroke thus resolving delays in health seeking after stroke which is a major barrier to fostering good acute stroke outcomes.[73-75] In resource-replete regions, telemedicine-based interventions, adapted to an mHealth-based platform, have been shown to expedite access to safe administration of thrombolytic treatment.[76-78] Nonetheless, it should be noted that despite the surge in mobile health applications, there are still comparatively few culturally appropriate and sustainable stroke-specific apps[79] and most published data focus on the pre-stroke or ultra-early stroke (within hours of onset) timepoints, not the post-stroke timepoints (days, weeks, months after onset), the latter of which is typical in LMIC. Enhancing post-stroke outcomes by addressing PSD via culturally relevant mHealth interventions will likely be a useful approach toward improving stroke outcomes in LMIC.

4 | THE WAY FORWARD FOR PSD

4.1 | Peru as a potential case and test study

As previously mentioned, stroke is a leading cause of death and disability in Peru,[11,12] a country where there is no national stroke program.[13] A stroke event in an average Peruvian family changes the life of the stroke survivor and caregivers in an economically and social manner. Additionally, a large number of stroke patients in Peru receive inadequate post-stroke care, far below evidence-based standards.[80] A similar situation is found for mental disorders which, despite their high burden and prevalence, are commonly underdiagnosed and barely treated. The treatment gap for mental disorders in Peru is between 75% and 85%, a situation explained by the scarcity and centralization of financial and human resources.[81] The plight of stroke survivors suffering PSD in Peru, ranging from 38% to 67% according to local studies,[24-26] is even worse, because dependency and impoverished conditions make it challenging to use ambulatory services, leading to inadequate monitoring.

Peru is an ideal setting to address PSD through mHealth because of these challenges, but mainly because recent improvements that must be seen as opportunities. First, there has been an enormous expansion of mobile technologies and Internet access. In 2013, 91% of households in Lima, Peru's capital, had at least one family member with access to a cell phone and 64% of Lima residents used the Internet.[82] The expected number of Peruvian smartphone users in 2018 is 10.5 million, almost twice the number in 2014.[83] Second, a mental health reform is underway in Peru,[84] aiming to guarantee availability of mental healthcare services through a community-based model.[84,85]

4.2 | Role of implementation science

As a mental health reform is currently taking place in Peru,[84] researchers need to plan their interventions foreseeing the possibility that these will have to be implemented in real situations, beyond experimentation-only approaches. Addressing post-stroke care and PSD in LMIC will necessitate engagement of policy makers and other stakeholders.[86] Hence, the evaluation of barriers and facilitators for both developing suitable interventions and their subsequent implementation is also warranted.[87] Recruiting adequate expertise within prevailing research teams in conducting mixed-methods studies and developing complex interventions would be important, including knowledge of hybrid effectiveness-implementation designs.[88] Implementation end points such as acceptability, adoption, appropriateness, feasibility, fidelity and costs, as well as sustainability would need to be defined and captured.[89,90] It is anticipated that "hybrid studies require more research expertise and personnel, and larger budgets, than non-hybrid designs."[88] Such a trade-off accommodates the advantages of discriminating what works and for whom in real-world settings.[90]

4.3 | An intervention concept to address PSD in Peru

Consideration could be given to designing, developing, and evaluating an evidence-based mHealth intervention to address PSD in a LMIC setting like Peru. Following a comprehensive review of the literature and assessment of expert scientific statements, as well as our own published and first-hand practical experience with scientific investigation and healthcare delivery in Peru, we propose a-three-phased approach named iMOODS—Investigating mHealth in overcoming occurrence of depression after stroke. The iMOODS intervention is based on building and delivering a digital platform to facilitate the self-management of PSD. By following three sequential phases, that is,

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formative, production, and integration + testing, we plan to bridge the several bottlenecks that hamper attending PSD in LMIC.

4.3.1 | Formative phase

This phase would aim to explore stroke patients' needs and perceptions regarding mental health treatment and to identify barriers and facilitators for the use of digital technologies among stroke patients. A qualitative approach needs to be used in this phase as it allows capture in-depth information not only from past and current experiences of stroke survivors but also from their future expectancies about the delivery of stroke care.

This qualitative study is also crucial to understand the intervention's context. This includes recognizing facilitators and barriers for the implementation of an adequate mHealth strategy to address PSD. Such information can be obtained from the main stakeholders involved in the delivery of stroke care. Thus, evidence from caregivers, healthcare providers, and policy makers would need to be collected triangulating different data collection techniques (see Box 1). Results obtained from this phase will be essential to better design, develop, and integrate the iMOODS intervention's components.

4.3.2 | Production phase

This phase would aim to develop the content and technological core components of an mHealth-based PSD self-management treatment strategy suitable for LMIC. As mentioned before, the core input for this phase would come from the qualitative information captured in the formative phase.

During this phase, particular attention should be paid to actively and continuously involve end users in the design, development, and validation of the contents and technology components of iMOODS. This engagement aims to guarantee that both contents and technology are understandable, appealing and usable by stroke patients, tailored to their needs, education, and culture. Just as in the formative phase, a qualitative approach will also be valuable to better identify the preference of the end users: the stroke survivors and their caregivers. The main objective for this phase would be to design and develop an mHealth system that helps stroke survivors to monitor and self-manage their PSD and allow them to access peer social support in a virtual environment. The educational and psychological contents and techniques included in the system need to be evidence based and practical, adapted from CBT principles to suit the context, capacities, and abilities of post-stroke users in LMIC. The mHealth intervention could have three interrelated core components: (i) PSD self-management app, (ii) online support group, and (iii) monitoring system. For each component, a specific set of contents, functionalities, and the appropriate development of mHealth technologies are described in Box 2. The production of these three components would require refinement and improvement using participatory procedures including co-design workshops with stroke survivors and caregivers, to guarantee a user-centered design.

4.3.3 | Integration and testing phase

This phase would aim to assemble all the components developed and test them, using effectiveness-implementation hybrid designs.[88] Hybrid designs are studies that allow to test the effects of an intervention while focusing on gathered information to also assess implementation outcomes.[89] In addition to demonstrate effectiveness, iMOODS requires to identify implementation strategies for challenging low-income settings to introduce evidence-based treatments for addressing PSD beyond the usual healthcare-channeled approaches (see Box 3).

To assess the implementation of the innovation and understand what worked, how and why, a mixed quantitative and qualitative methods approach for implementation science methodology would have to be used.[90,91] iMOODS will require to define, a priori, some implementation outcomes: acceptability, adoption, appropriateness, feasibility, fidelity, and cost.[89] Different data collection methods could be considered. First, focus groups and short surveys with participants would elicit their preferences. Second, the iMOODS monitoring system will automatically collect and store data directly from the app that will describe in detail the participants' adherence and use of the tool. With regard to the intervention itself, assessment of depressive symptoms and other secondary outcomes will be measured and analyzed before and after the intervention. At the end of the intervention, a questionnaire and a semi-structured interview guide could collect

Box 1 iMOODS formative phase

Key informants

Different people involved in the stroke care should be selected to take part in the first phase, for example, stroke survivors, caregivers, and healthcare providers with stroke working experience including professionals from psychology, psychiatry, neurology, and physiotherapy backgrounds. Engineers developing mHealth solutions for people with stroke and/or disabilities should be also considered.

Data collection methods

A semi-structured interview guide should be designed for each type of informant, and all interviewees should answer a brief questionnaire to collect demographic data and information about technology usage. Observations would need to be performed at stroke survivors' houses to assess Internet connectivity and use of technology devices in a real situation and to identify potential barriers for the following stages of the iMOODS Project.

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Box 2 iMOODS production phase

iMOODS core components

PSD self-management application. The app would include a set of interactive sessions, delivered several times per week. The sessions will be a combination of text/audios, videos, quizzes, and interactive activities, aimed to increase patients' management of their condition and improve their mood. The app includes reminders to promote medication adherence, information of mental care services, etc.

Online support group platform. This platform would aim to take advantage of technology to offer the potential benefits of peer support, even when the stroke survivor has limited mobility or has a reduced social life because of depression. It should be available to all app users and including weekly group sessions, facilitated by a healthcare provider, but also forums and private chat rooms to be used on demand.

Monitoring system. This Web-based system should collect real-time information from all the app users. It should allow the project team to monitor participants' compliance with the intervention activities, to identify if somebody has no connectivity or needs help. It should also automatically store information to be used in the process evaluation of the intervention, that is, frequency of use of the app, favorite sessions, etc.

Data collection methods

Interviews and focus groups with both patients with PSD and their caregivers would capture user's acceptability and satisfaction data with the assembled package. Some usability evaluation techniques and tools, for example, http://www.usability.gov/, would explore the user experience from a different perspective, the commercial perspective, focused in what is needed to keep users engaged with and attached to the product.

Box 3 iMOODS testing phase

Participants

Patients with PSD would be eligible, including both prevalent and incident cases. Patients with a diagnosis of stroke within 6 months of onset, regardless of stroke subtype, and with clinically significant depressive symptoms (PHQ-9 score ≥10) would be considered eligible. Patients with moderate or high suicide risk should be excluded and referred for adequate mental health care. Fieldworkers can assess eligibility and recruit patients with PSD at external consultations and rehabilitation services in both hospitals, using simple, validated, screening questionnaires that allow them to identify stroke to a somewhat reasonable degree as well as stroke neurologists. The Questionnaire for Verifying Stroke-Free Status (QVSFS)[92] and Del Brutto's Spanish version[93] are both effective at identifying stroke-free individuals with a high degree of accuracy and also have good accuracy as a screening tool for identifying subjects with stroke and/or transient ischemic attacks.

Training and technical support

Patients and caregivers—to provide support at home if necessary—would need to be trained in the use of iMOODS app and other components. Today, smartphones provide a suitable delivery channel to deploy training and intervention activities. Training videos, installed in the device, would be a necessary.

Outcomes and other measurements

Main outcome would be a reduction of at least 5 points in the PHQ-9 scale for the assessment of depressive symptoms.[94] PHQ-9 is a pragmatic and easy-to-use instrument that has been tested and recommended to measure depression in stroke patients.[95] Other variables that merit consideration for its collection, in addition to demographic and socioeconomic data, would include medication adherence (Morisky), activities of daily living and physical functioning (Barthel Index), dependency and disability (Modified Rankin Scale), quality of life (EQ-5D), and social support.

information about participants' use of the application and their participation and interaction in the online support group, for example, frequency, favorite features, difficulties, etc. Also, participants should be invited to reflect on the perceived benefits on their mental and physical health; suggestions to improve them will be administered. All participants and caregivers, or a subsample, could be invited to a post-study evaluation.

5 | CONCLUSIONS

The proposed iMOODS study concept cross-fertilizes the fields of mental health, stroke management, rehabilitation, information technology, and health systems, targeting a major problem such as PSD, affecting the most disenfranchised. It also applies synergistic constructs from behavioral and technology's uptake and usability theories

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with direct user involvement. This combination is pragmatically translated into accruing values, opinion, and guidance from stroke patients, caregivers, providers, and engineers, as well as blended with evidence from current expert consensus clinical practice management guidelines. Importantly, from an implementation science perspective, iMOODS looks into facilitating integration across different tiers of healthcare facilities in Peru, thereby aligning with the SDGs and enhancing knowledge about the complexity of health interventions, and especially the nature of the challenges encountered in low-resource settings and for populations traditionally underrepresented in research. Altogether, the resulting product, if proven effective, may eventually be exported as a feasible and cost-efficient model of healthcare worker and caregiver involvement for the provision of high-quality standardized mental health care and PSD support for underserved US areas, and other LMIC settings.

ACKNOWLEDGEMENTS

To Katie Sacksteder for the editorial support in earlier versions of this manuscript.

CONFLICTS OF INTEREST

There are no conflicts of interest to declare.

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REFERENCES

1. United Nations. *Sustainable Development Knowledge Platform*. New York: Division for Sustainable Development, Department of Economic and Social Affairs, United Nations. https://sustainabledevelopment.un.org/. Accessed September 1, 2017.
2. Bennett DA, Krishnamurthi RV, Barker-Collo S, et al. The global burden of ischemic stroke: findings of the GBD 2010 study. *Glob Heart*. 2014;9:107-112.
3. Krishnamurthi RV, Moran AE, Forouzanfar MH, et al. The global burden of hemorrhagic stroke: a summary of findings from the GBD 2010 study. *Glob Heart*. 2014;9:101-106.
4. Yan LL, Li C, Chen J, et al. Prevention, management, and rehabilitation of stroke in low- and middle-income countries. *eNeurologicalSci*. 2016;2:21-30.
5. di Carlo A. Human and economic burden of stroke. *Age Ageing*. 2009;38:4-5.
6. Ovbiagele B, Goldstein LB, Higashida RT, et al. Forecasting the future of stroke in the United States: a policy statement from the American Heart Association and American Stroke Association. *Stroke*. 2013;44:2361-2375.
7. Centers for Disease Control and Prevention (CDC). Prevalence and most common causes of disability among adults–United States, 2005. *MMWR Morb Mortal Wkly Rep*. 2009;58:421-426.
8. Go AS, Mozaffarian D, Roger VL, et al. Executive summary: heart disease and stroke statistics–2014 update: a report from the American Heart Association. *Circulation*. 2014;129:399-410.
9. Hardie K, Hankey GJ, Jamrozik K, Broadhurst RJ, Anderson C. Ten-year risk of first recurrent stroke and disability after first-ever stroke in the Perth Community Stroke Study. *Stroke*. 2004;35:731-735.
10. GBD Mortality and Causes of Death Collaborators. Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet*. 2015;385:117-171.
11. Castaneda-Guarderas A, Beltran-Ale G, Casma-Bustamante R, Ruiz-Grosso P, Malaga G. [Registry of patients with stroke stated in a public hospital of Peru, 2000-2009]. *Rev Peru Med Exp Salud Publica*. 2011;28:623-627.
12. Davalos LF, Malaga G. [Stroke in Peru: a forgotten and unattended prevalent disease]. *Rev Peru Med Exp Salud Publica*. 2014;31:400-401.
13. Avezum A, Costa-Filho FF, Pieri A, Martins SO, Marin-Neto JA. Stroke in Latin America: Burden of Disease and Opportunities for Prevention. *Glob Heart*. 2015;10:323-331.
14. Velázquez A, Cachay C, Munayco C, Poquioma E, Espinoza R, Seclén Y. [La carga de enfermedad y lesiones en el Perú]. Lima: Ministerio de Salud, 2008.
15. Prencipe M, Ferretti C, Casini AR, Santini M, Giubilei F, Culasso F. Stroke, disability, and dementia: results of a population survey. *Stroke*. 1997;28:531-536.
16. Hasin DS, Goodwin RD, Stinson FS, Grant BF. Epidemiology of major depressive disorder: results from the National Epidemiologic Survey on Alcoholism and Related Conditions. *Arch Gen Psychiatry*. 2005;62:1097-1106.
17. Ayerbe L, Ayis S, Crichton S, Wolfe CD, Rudd AG. The natural history of depression up to 15 years after stroke: the South London Stroke Register. *Stroke*. 2013;44:1105-1110.
18. Parikh RM, Robinson RG, Lipsey JR, Starkstein SE, Fedoroff JP, Price TR. The impact of poststroke depression on recovery in activities of daily living over a 2-year follow-up. *Arch Neurol*. 1990;47:785-789.
19. Robinson RG, Bolla-Wilson K, Kaplan E, Lipsey JR, Price TR. Depression influences intellectual impairment in stroke patients. *Br J Psychiatry*. 1986;148:541-547.
20. Kutlubaev MA, Hackett ML. Part II: predictors of depression after stroke and impact of depression on stroke outcome: an updated systematic review of observational studies. *Int J Stroke*. 2014;9:1026-1036.
21. Bartoli F, Lillia N, Lax A, et al. Depression after stroke and risk of mortality: a systematic review and meta-analysis. *Stroke Res Treat*. 2013;2013:862978.
22. Ayerbe L, Ayis S, Wolfe CD, Rudd AG. Natural history, predictors and outcomes of depression after stroke: systematic review and meta-analysis. *Br J Psychiatry*. 2013;202:14-21.
23. Ayerbe L, Ayis S, Rudd AG, Heuschmann PU, Wolfe CD. Natural history, predictors, and associations of depression 5 years after stroke: the South London Stroke Register. *Stroke*. 2011;42:1907-1911.
24. Rojas-Huerto E, Villanueva-Ruska A. [Influencia de la depresión posterior a la enfermedad vascular cerebral en la recuperación física de los pacientes con secuela motora]. *Rev Per Neurol* 2012;12:15-20.
25. Guerra M, Ferri CP, Sosa AL, et al. Late-life depression in Peru, Mexico and Venezuela: the 10/66 population-based study. *Br J Psychiatry*. 2009;195:510-515.
26. Ferri CP, Schoenborn C, Kalra L, et al. Prevalence of stroke and related burden among older people living in Latin America, India and China. *J Neurol Neurosurg Psychiatry*. 2011;82:1074-1082.
27. Atun R. Transitioning health systems for multimorbidity. *Lancet*. 2015;386:721-722.
28. Daar AS, Singer PA, Persad DL, et al. Grand challenges in chronic non-communicable diseases. *Nature*. 2007;450:494-496.
29. Miranda JJ, Moscoso MG, Yan LL, et al. Addressing post-stroke care in rural areas with Peru as a case study. Placing emphasis on evidence-based pragmatism. *J Neurol Sci* 2017;375:309-315.

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30. Ojagbemi A, Owolabi M, Akinyemi R, et al. Prevalence and predictors of anxiety in an African sample of recent stroke survivors. *Acta Neurol Scand*. 2017;136:617-623.
31. World Health Organization. mhGAP Mental Health Gap Action Programme. Scaling Up Care for Mental, Neurological, and Substance Use Disorders. Geneva: World Health Organization, 2008.
32. Chen Y, Guo JJ, Zhan S, Patel NC. Treatment effects of antidepressants in patients with post-stroke depression: a meta-analysis. *Ann Pharmacother*. 2006;40:2115-2122.
33. Hackett ML, Anderson CS, House A, Xia J. Interventions for treating depression after stroke. *Cochrane Database Syst Rev*. 2008;(4):CD003437.
34. Ministerio De Salud. Informe sobre los servicios de salud mental del subsector Ministerio de Salud del Perú 2008. Lima: Ministerio de Salud, 2008.
35. Stalder-Luthy F, Messerli-Burgy N, Hofer H, Frischknecht E, Znoj H, Barth J. Effect of psychological interventions on depressive symptoms in long-term rehabilitation after an acquired brain injury: a systematic review and meta-analysis. *Arch Phys Med Rehabil*. 2013;94:1386-1397.
36. Lincoln NB, Flannaghan T, Sutcliffe L, Rother L. Evaluation of cognitive behavioural treatment for depression after stroke: a pilot study. *Clin Rehabil*. 1997;11:114-122.
37. Kneebone II, Dunmore E. Psychological management of post-stroke depression. *Br J Clin Psychol* 2000;1:53-65.
38. Laidlaw K. Post-Stroke Depression and CBT with Older People In: Gallagher Thompson D, Steffen A, Thompson LW, eds. *Handbook of Behavioral and Cognitive Therapies with Older Adults*. New York: Springer; 2008: 233-248.
39. Karyotaki E, Riper H, Twisk J, et al. Efficacy of Self-guided Internet-Based Cognitive Behavioral Therapy in the Treatment of Depressive Symptoms: A Meta-analysis of Individual Participant Data. *JAMA Psychiatry*. 2017;74:351-359.
40. Twomey C, O'Reilly G, Byrne M. Effectiveness of cognitive behavioural therapy for anxiety and depression in primary care: a meta-analysis. *Fam Pract*. 2015;32:3-15.
41. Cuijpers P, Andersson G, Donker T, van Straten A. Psychological treatment of depression: results of a series of meta-analyses. *Nord J Psychiatry*. 2011;65:354-364.
42. Cuijpers P, Karyotaki E, Pot AM, Park M, Reynolds CF 3rd. Managing depression in older age: psychological interventions. *Maturitas*. 2014;79:160-169.
43. Serfaty MA, Haworth D, Blanchard M, Buszewicz M, Murad S, King M. Clinical effectiveness of individual cognitive behavioral therapy for depressed older people in primary care: a randomized controlled trial. *Arch Gen Psychiatry*. 2009;66:1332-1340.
44. Huang CQ, Dong BR, Lu ZC, Yue JR, Liu QX. Chronic diseases and risk for depression in old age: a meta-analysis of published literature. *Ageing Res Rev*. 2010;9:131-141.
45. Webb CA, Rosso IM, Rauch SL. Internet-Based Cognitive-Behavioral Therapy for Depression: Current Progress and Future Directions. *Harv Rev Psychiatry*. 2017;25:114-122.
46. Twomey C, O'Reilly G, Meyer B. Effectiveness of an individually-tailored computerised CBT programme (Deprexis) for depression: A meta-analysis. *Psychiatry Res*. 2017;256:371-377.
47. Twomey C, O'Reilly G. Effectiveness of a freely available computerised cognitive behavioural therapy programme (MoodGYM) for depression: meta-analysis. *Aust N Z J Psychiatry*. 2017;51:260-269.
48. Jonassaint CR, Gibbs P, Belnap BH, Karp JF, Abebe KK, Rollman BL. Engagement and outcomes for a computerised cognitive-behavioural therapy intervention for anxiety and depression in African Americans. *BJPsych Open*. 2017;3:1-5.
49. Waller R, Gilbody S. Barriers to the uptake of computerized cognitive behavioural therapy: a systematic review of the quantitative and qualitative evidence. *Psychol Med*. 2009;39:705-712.
50. Simblett SK, Yates M, Wagner AP, et al. Computerized Cognitive Behavioral Therapy to Treat Emotional Distress After Stroke: A Feasibility Randomized Controlled Trial. *JMIR Ment Health*. 2017;4:e16.
51. Munoz RF. Using evidence-based internet interventions to reduce health disparities worldwide. *J Med Internet Res*. 2010;12:e60.
52. Lennon S, McKenna S, Jones F. Self-management programmes for people post stroke: a systematic review. *Clin Rehabil*. 2013;27:867-878.
53. Bjorneklett HG, Lindemalm C, Rosenblad A, et al. A randomised controlled trial of support group intervention after breast cancer treatment: results on anxiety and depression. *Acta Oncol*. 2012;51:198-207.
54. Montazeri A, Jarvandi S, Haghighat S, et al. Anxiety and depression in breast cancer patients before and after participation in a cancer support group. *Patient Educ Couns*. 2001;45:195-198.
55. Chu H, Yang CY, Liao YH, et al. The effects of a support group on dementia caregivers' burden and depression. *J Aging Health*. 2011;23:228-241.
56. Perez-Rojas JE, del Pilar Torres-Arreola L. [Social support in the rehabilitation of patients with disabilities due to stroke]. *Rev Med Inst Mex Seguro Soc* 2012;50:249-254.
57. Labrique AB, Vasudevan L, Kochi E, Fabricant R, Mehl G. mHealth innovations as health system strengthening tools: 12 common applications and a visual framework. *Glob Health Sci Pract*. 2013;1:160-171.
58. Andersson G, Cuijpers P. Internet-based and other computerized psychological treatments for adult depression: a meta-analysis. *Cogn Behav Ther*. 2009;38:196-205.
59. van Voorhees BW, Mahoney N, Mazo R, et al. Internet-based depression prevention over the life course: a call for behavioral vaccines. *Psychiatr Clin North Am*. 2011;34:167-183.
60. Van't Hof E, Cuijpers P, Stein DJ. Self-help and Internet-guided interventions in depression and anxiety disorders: a systematic review of meta-analyses. *CNS Spectr* 2009;14:34-40.
61. Andrews G, Cuijpers P, Craske MG, McEvoy P, Titov N. Computer therapy for the anxiety and depressive disorders is effective, acceptable and practical health care: a meta-analysis. *PLoS ONE*. 2010;5:e13196.
62. Berrouiguet S, Baca-Garcia E, Brandt S, Walter M, Courtet P. Fundamentals for Future Mobile-Health (mHealth): A Systematic Review of Mobile Phone and Web-Based Text Messaging in Mental Health. *J Med Internet Res*. 2016;18:e135.
63. Griffiths KM, Farrer L, Christensen H. The efficacy of internet interventions for depression and anxiety disorders: a review of randomised controlled trials. *Med J Aust*. 2010;192:S4-S11.
64. Beratarrechea A, Diez-Canseco F, Irazola V, Miranda J, Ramirez-Zea M, Rubinstein A. Use of m-Health Technology for Preventive Interventions to Tackle Cardiometabolic Conditions and Other Non-Communicable Diseases in Latin America- Challenges and Opportunities. *Prog Cardiovasc Dis*. 2016;58:661-673.
65. Maiorana A, Kegeles S, Salazar X, Konda K, Silva-Santisteban A, Caceres C. 'Proyecto Orgullo', an HIV prevention, empowerment and community mobilisation intervention for gay men and transgender women in Callao/Lima, Peru. *Glob Public Health*. 2016;11:1076-1092.
66. Torres LD, Barrera AZ, Delucchi K, Penilla C, Perez-Stable EJ, Munoz RF. Quitting smoking does not increase the risk of major depressive episodes among users of Internet smoking cessation interventions. *Psychol Med*. 2010;40:441-449.
67. Bernocchi P, Vanoglio F, Baratti D, et al. Home-based telesurveillance and rehabilitation after stroke: a real-life study. *Top Stroke Rehabil*. 2016;23:106-115.
68. Chumbler NR, Quigley P, Li X, et al. Effects of telerehabilitation on physical function and disability for stroke patients: a randomized, controlled trial. *Stroke*. 2012;43:2168-2174.

16000404, 2018, 1, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/ane.12832 by Cochrane Peru, Wiley Online Library on [22/04/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

69. Crotty M, Killington M, van den Berg M, Morris C, Taylor A, Carati C. Telerehabilitation for older people using off-the-shelf applications: acceptability and feasibility. *J Telemed Telecare*. 2014;20:370-376.
70. Forducey PG, Glueckauf RL, Bergquist TF, Maheu MM, Yutsis M. Telehealth for persons with severe functional disabilities and their caregivers: facilitating self-care management in the home setting. *Psychol Serv*. 2012;9:144-162.
71. Johansson R, Andersson G. Internet-based psychological treatments for depression. *Expert Rev Neurother* 2012;12:861-869. quiz 70.
72. Huguet A, Rao S, McGrath PJ, et al. A Systematic Review of Cognitive Behavioral Therapy and Behavioral Activation Apps for Depression. *PLoS ONE*. 2016;11:e0154248.
73. Dubey D, Amritphale A, Sawhney A, Amritphale N, Dubey P, Pandey A. Smart phone applications as a source of information on stroke. *J Stroke*. 2014;16:86-90.
74. Nam HS, Heo J, Kim J, et al. Development of smartphone application that aids stroke screening and identifying nearby acute stroke care hospitals. *Yonsei Med J*. 2014;55:25-29.
75. You JS, Park S, Chung SP. Mobile message for a better stroke recognition: the new concept of national campaign. *Stroke* 2008;39:e42. author reply e3.
76. Bagot KL, Cadilhac DA, Hand PJ, Vu M, Bladin CF. Telemedicine expedites access to optimal acute stroke care. *Lancet*. 2016;388:757-758.
77. Belt GH, Felberg RA, Rubin J, Halperin JJ. In-Transit Telemedicine Speeds Ischemic Stroke Treatment: Preliminary Results. *Stroke*. 2016;47:2413-2415.
78. Sharma S, Padma MV, Bhardwaj A, Sharma A, Sawal N, Thakur S. Telestroke in resource-poor developing country model. *Neurol India*. 2016;64:934-940.
79. Singer J, Levine SR. Stroke and technology: prescribing mHealth apps for healthcare providers, patients and caregivers – a brief, selected review. *Future Neurol*. 2016;11:109-112.
80. Norrving B, Kissela B. The global burden of stroke and need for a continuum of care. *Neurology*. 2013;80:S5-S12.
81. World Health Organization. *Mental Health Action Plan 2013–2020*. Geneva: WHO; 2013.
82. Instituto Nacional de Estadística e Informática. Estadísticas de las Tecnologías de Información y Comunicación en los Hogares Octubre - Noviembre - Diciembre 2013. Lima: Instituto Nacional de Estadística e Informática, 2014.
83. Marketing Mobile Peru. En Perú más de 7 millones usarán smartphones al finalizar el 2015, 2015.
84. Miranda JJ, Diez-Canseco F, Araya R, et al. Transitioning mental health into primary care. *Lancet Psychiatry*. 2017;4:90-92.
85. *Decreto Supremo N° 033-2015-SA*. Lima: El Peruano, 2015. http://busquedas.elperuano.com.pe/normaslegales/aprueban-el-reglamento-de-la-ley-n-29889-ley-que-modifica-decreto-supremo-n-033-2015-sa-1296283-1/. Accessed September 1, 2017
86. Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC. Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science. *Implement Sci*. 2009;4:50.
87. Fogarty International Center. *Toolkit: Overcoming Barriers to Implementation in Global Health*. Bethesda, MD: National Institutes of Health.
88. Curran GM, Bauer M, Mittman B, Pyne JM, Stetler C. Effectiveness-implementation hybrid designs: combining elements of clinical effectiveness and implementation research to enhance public health impact. *Med Care*. 2012;50:217-226.
89. Proctor E, Silmere H, Raghavan R, et al. Outcomes for implementation research: conceptual distinctions, measurement challenges, and research agenda. *Adm Policy Ment Health*. 2011;38:65-76.
90. Peters DH, Adam T, Alonge O, Agyepong IA, Tran N. Implementation research: what it is and how to do it. *BMJ*. 2013;347:f6753.
91. Epstein JN, Langberg JM, Lichtenstein PK, Kolb R, Altaye M, Simon JO. Use of an Internet portal to improve community-based pediatric ADHD care: a cluster randomized trial. *Pediatrics*. 2011;128:e1201-e1208.
92. Jones WJ, Williams LS, Meschia JF. Validating the Questionnaire for Verifying Stroke-Free Status (QVSFS) by neurological history and examination. *Stroke*. 2001;32:2232-2236.
93. del Brutto OH, Idrovo L, Mosquera A, et al. [Validation of a screening questionnaire for stroke detection in Spanish-speaking communities]. *Rev Neurol*. 2004;39:301-304.
94. Moore M, Ali S, Stuart B, et al. Depression management in primary care: an observational study of management changes related to PHQ-9 score for depression monitoring. *Br J Gen Pract*. 2012;62:e451-e457.
95. Williams LS, Brizendine EJ, Plue L, et al. Performance of the PHQ-9 as a screening tool for depression after stroke. *Stroke*. 2005;36:635-638.

How to cite this article: Miranda JJ, Moscoso MG, Toyama M, Cavero V, Diez-Canseco F, Ovbiagele B. Role of mHealth in overcoming the occurrence of post-stroke depression. *Acta Neurol Scand*. 2018;137:12–19. https://doi.org/10.1111/ane.12832

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