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RESEARCH

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Applying the World Stroke Organization roadmap in planning a model for stroke service implementation in Matrouh Governorate-Egypt: a World Stroke Organization young future stroke leaders' analytical study

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Abstract

Background The global incidence of stroke is on the rise, primarily due to an increase in the aging population and the prevalence of vascular risk factors among the elderly. However, stroke is a treatable condition if promptly recognized and managed effectively. To optimize stroke management, it is crucial to establish a well-prepared infrastructure comprising adequately trained physicians working in collaboration with multidisciplinary teams. Equipped stroke units, easily accessible emergency medical services with a stroke code, and interconnected telestroke networks, further enhance stroke care delivery. Along with the current study, conducted by a task force from the World Stroke Organization's Future Stroke Leaders Program, an assessment of the stroke infrastructure within Matrouh governorate in Egypt for stepwise implementation of stroke services, based on the World Stroke Organization's stroke roadmap took place. The study consisted of two levels: Level One involved analyzing existing gaps that may impede the implementation of stroke services, while Level Two proposed strategies to address these gaps using a problem-solving approach.

Results The study identified the Matrouh governorate as a suitable region for stroke service implementation. The region exhibits a blend of urban and rural areas and is geographically distant from major healthcare centers. Matrouh also possesses a diverse population, subject to seasonal variations. Currently, it offers a mix of minimum and essential stroke services, which can be expanded and improved through a step-by-step approach guided by the World Stroke Organization's stroke roadmap.

Conclusions Mapping stroke infrastructures allows for the identification of potential gaps to optimize the potential for implementation of stroke services.

Keywords Stroke implementation, World Stroke Organization roadmap, Future Stroke Leaders, Matrouh

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Background

Stroke, despite being a non-communicable disease, remains a significant global cause of both mortality and morbidity [1]. It is estimated that one-third of stroke cases die and one-third live with disability [2].

Such a burden of stroke affects the global economy not because of direct costs related to diagnosis and management, but more importantly through indirect costs that are evident in losing manpower because of disability or caregiver absenteeism. Long-term stroke care expenses further contribute to the overall economic impact [3].

Stroke units have emerged as a crucial component in stroke management, as many studies and guidelines found that the outcomes of patients managed in stroke units are much better than those managed in conventional care [4].

Despite that stroke guidelines are presented and published by the World Stroke Organization (WSO) in the stroke roadmap [5], the American Heart Association/American Stroke Association [6], and the European Stroke Organization [7, 8] it is imperative to adapt these guidelines to the unique circumstances of each country.

High-income countries usually face fewer challenges in dealing with stroke with a well-designed stroke service distributed along stroke centers, stroke units, stroke-ready hospitals, and in the presence of the hub and spoke model, along with the availability of emergency medical services (EMS), mobile computed tomography ambulances, as well as air transportation if needed [9].

Conversely, low- and middle-income countries (LMICs) encounter significant obstacles, including a scarcity of stroke units outside urban areas and inadequate transportation infrastructure, often forcing patients to rely on private means to reach hospitals [10].

LMICs comprise many rural areas, governorates, and regions that are away from the central capitals and major cities. Despite accounting for a significant portion of the population, these areas typically lack advanced and specialized healthcare facilities, relying primarily on basic health services [11].

It is worth mentioning that the neurology specialty is also scarce in LMICs to the degree that some areas are covered by a single neurologist for each 6000 up to 4 million population [12, 13]. Neurology specialty is deficient in Africa to the extent that 36 out of the 54 African countries have only from 1 to 30 neurologists throughout the entire country and 10 African countries do not have neurology specialty [13].

In light of these circumstances, Future Stroke Leaders within the WSO Future Leaders program undertook a study in Matrouh governorate, Egypt, employing it as a model to identify gaps in stroke services and propose an approach to bridge these gaps for effective stroke service implementation. This model holds potential for application in other LMICs with similar characteristics, encompassing rural, border, and regions with varying population densities.

Methods

An infrastructural model for stroke care, analyzed by a task force of the Future Stroke Leaders as part of the WSO Future Stroke Leaders' Program, is presented as a pathway model for implementing stroke services in various regions.

The model took the WSO roadmap as a guide. The WSO roadmap for quality stroke care encompasses several stages that involve assessing the existing structures and identifying the necessary improvements. This roadmap outlines what needs to be done, how it should be done, and highlights areas that require enhancement [4].

Within the WSO roadmap healthcare facilities are divided into minimal, essential, and advanced.

The minimal level provides healthcare through uncoordinated local communities with no care for hyperacute stroke, and with limited access to trained physicians or healthcare workers in the field of stroke.

As for the essential level, it has stroke care facilities and training. There is an availability of basic stroke diagnostics including rapid diagnosis protocols and the presence of trained physicians, nurses, and interdisciplinary stroke teams, access to recombinant tissue plasminogen activator (rtPA) yet, limited access to emergency medical services (EMS), and coordinated services along wider geographical areas.

The advanced level is similar to the essential one yet, with additional fully coordinated stroke service, telestroke, data collection, advanced diagnostics, and advanced interventions.

The current model consisted of two levels: level one involved carefully selecting a region for in-depth study, and identifying its gaps including demographics, geography, and health status, which involved both physical facilities and medical human resources.

The selected region was based on: the degree of stroke burden of the region, the availability of minimal facility hospitals that could be shifted to essential stroke-service-providing hospitals, the availability of thrombolytic therapy within the region/country that could be transferred to the desired hospitals, paved roads and pathways that connect the region, and the availability of physicians that could be depended upon.

Level two focused on addressing the identified gaps through a tailored approach that took into account the stroke roadmap and relevant stroke guidelines. Strategies included allocating neurologists or training internists, emergency units' specialists, and general practitioners to

deal with stroke (medical human resources), raising the capabilities of hospitals and turning some to stroke units (infrastructure), introducing telestroke services (technology aids), increasing awareness and EMS engagement, and following up through database registries.

Level two could be divided into sub-levels with timely intervals according to individual regions' progress, status, and capabilities.

After considering various regions and the accessibility of data, Egypt was deemed a suitable model due to its status as a LMIC where stroke services have been implemented over the past decade. Egypt exhibits a mix of regions with well-managed stroke services and others that require further attention. Consequently, choosing a region within Egypt as a model holds promise for replication in other LMICs [14].

Data collection and analysis were done through a site visit to the governorate as well as collecting data from government official agencies such as the Ministry of Health (MOH), Ministry of Planning and Economic Development, and the Central Agency for Public Mobilization and Statistics (CAPMAS) [15–17], the estimated number of strokes was calculated based on age-specific incidence and replicating the analysis done by Farghaly and colleagues in the Al-Kharga district since demographically wise it resembled Matrouh governorate [18].

Results

Studying Matrouh Governorate as a Region, Demographics and Geographics: Matrouh Governorate is situated in the northwest of Egypt, it extends for approximately 500 km along the Mediterranean coast, positioned between Alexandria to the east and the international borders with Libya to the west.

The population of the governorate is approximately 500,000 distributed along a few major cities along the coast with the majority in the capital of the governorate which is 500 km from Cairo with a mixture of urban and rural areas.

Matrouh is divided into eight municipal divisions, as a coastal governorate, Matrouh faces an additional challenge which is a seasonal summer migration. From mid-June to early October, the region experiences an influx of approximately 5 million individuals, primarily families from Cairo who own or rent apartments along the entire north coast. During this period, children are sometimes left with their grandparents in Matrouh throughout the week, as parents or at least one of them often return to Cairo for work and return to Matrouh on weekends.

In addition to the 5 million holiday migration, the Matrouh population is also likely to increase within the next few years as the government is establishing a major urbanization project in El Alamein division that is supposed to attract an additional 5 million by the year 2030 to make the population close to 7 million.

Health status physical facilities: the governmental hospitals within Matrouh governorate until 2020 were 5 with a total of 468 beds and 76 intensive care unit beds with 60 ambulance units accounting for 3.9% of the entire Egypt ambulance units.

Based on the Task Force research, 7 hospitals were identified with a total of 630 beds accounting for 1.2 beds per 1000 population (the global average of beds per 1000 population is 2.9 and the national average is 1.3) and an additional 3 private hospitals with 107 beds. Out of the 7 hospitals, only 2 were approaching the classification of essential healthcare stroke providers (Table 1).

The average length of stay within Matrouh hospitals (total length of stay within a specific time interval in a hospital/total discharged patients within the same time interval in the same hospital) was 1.4 days and the rotation of the bed (total discharged patients within a specific time interval in a hospital/total number of beds within the same hospital) was 79.5.

Raising the capabilities of hospitals and turning some into stroke units: 2 hospitals namely El Alamein Typical Hospital and Matrouh General Hospital, had the necessary infrastructure to be called essential healthcare stroke providers according to the WSO roadmap after fulfilling some requirements.

Both hospitals were well equipped with imaging such as computed tomography machines (CT) and magnetic resonance imaging (MRI), ultrasonic devices for vessel integrity analysis, cardiac investigation techniques such as ECHO, and laboratories. Besides El Alamein Typical Hospital was recently equipped with an Angio suite.

However, neither of these hospitals had a dedicated stroke unit. Furthermore, there was a deficiency in well-trained physicians and nursing staff in stroke management. Despite the government's endorsement of thrombolysis, it was not readily available in the pharmacies of Matrouh hospitals. Moreover, EMS with code stroke were not well established.

Health status medical human resources: Out of 93,012 on-duty physicians within the governmental sector; Matrouh had only 931 and out of them there were only 4 specialized in the field of neurological sciences (neurosurgery or neurology), while there were 34 internists, 18 intensivists, 30 radiologists, 7 physical medicine, and 21 emergency unit specialists.

As for nursing power, Matrouh had 1422 out of 55,217 on duty within the governmental sector. Related paramedical field manpower within Matrouh that is needed in serving and establishing stroke service was distributed as follows: 117 laboratory technicians, 57

Table 1 Hospitals within Matrouh Governorate as identified by the task force and their WSO roadmap status level

Hospital name	Municipal division and residential status	Catchment area density	Site (on Alexandria Matrouh desert road)	Capacity (excluding specialized beds)	Status level according to WSO roadmap
El Hamam central hospital	El Hamam urban/rural	65,780	64 km	86 ward beds and 11 ICU	Minimal
Marina central hospital	El Alamein rural	12,398	95 km	47 ward beds and 3 ICU	Minimal
El Alamein typical hospital	El Alamein rural	12,398	107 km	47 ward beds and 20 ICU	Essential
Dabaa central hospital	El Dabaa urban/rural	61,363	160 km	55 ward beds and 10 ICU	Minimal
Mersa Matrouh general hospital	Mersa Matrouh urban/rural	241,625	In the capital of the governorate (500 km from Cairo)	310 ward beds and 29 ICU	Essential
El Negaila central hospital	El Negaila urban/rural	34,593	245 km	43 ward beds and 9 ICU	Minimal
Barrani central hospital	Sidi Barrani urban/rural	66,319 within Sidi Barrani, 20,479 within Sallum, 35,901 within Siwa Oasis	260 km	42 ward beds and 10 ICU	Minimal

Specialized beds: beds dedicated to renal dialysis or neonatal care units, ICU: intensive care unit

radiology technicians, 220 nursing technicians, and 16 physical therapists.

Stroke service implementation: Estimating stroke cases in the current model (the official population of Matrouh besides the travelers from Cairo): until finalizing this analytical study, there was no official data available regarding the number of stroke cases in Matrouh Governorate, either in general or during the

Table 2 Estimated number of strokes in Matrouh governorate in summer (the regular population + travelers for vacation)

Incidence	< 20 years	20–39 years	40–59 years	60 + years		
Matrouh	214,301	134,864	61,292	15,167		
Cairo	3,433,324	3,240,994	2,053,292	812,063		
Expected numbers						
Incidence (per 1000)	**Thrombotic**	**Embolic**	**Matrouh**	**Cairo**		
< 20 years	0.01	0	2	34		
20–39 years	0.4	0.05	61	1458		
40–59 years	3	0.2	196	6570		
60 + years	15.5	2.8	277	14,861		
Total			536	22,923	23,459	1992[a]
						1856
Incidence (per 1000)	**All cerebrovascular strokes**		**Matrouh**	**Cairo**		
< 20 years	0.04		9	137		
20–39 years	0.59		80	1912		
40–59 years	4.5		276	9240		
60 + years	23.1		350	18,759		
Total			714	30,048	30,762	24,610[b]
						2019
						1876

[a] Assuming 50% over the age of 60 travel from Cairo to Matrouh and stay for 3 months in summer

[b] 80% are ischemic strokes

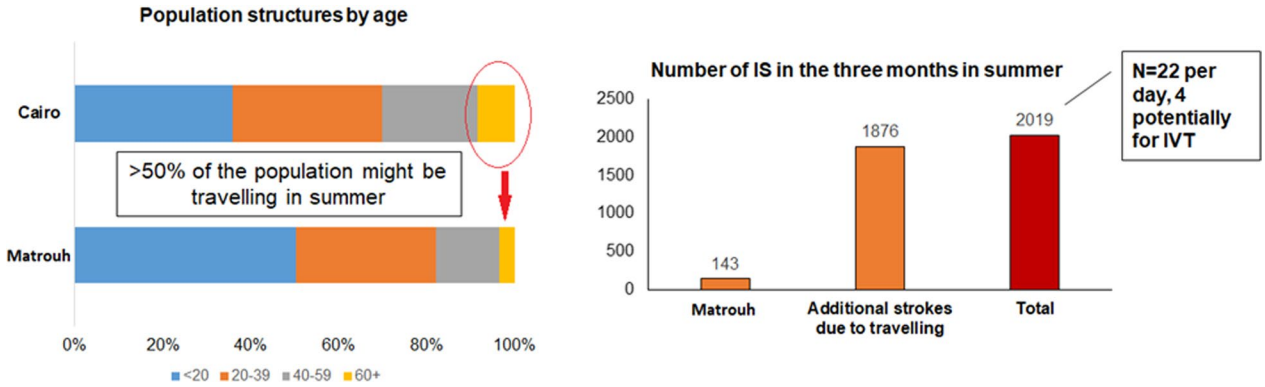

Fig. 1 Population of Cairo and Matrouh, the estimated number of ischemic strokes along high season (summer months)

summer season yet, it is estimated that annual stroke cases in Egypt range between 150,000 and 210,000.

Age-specific incidence in Egypt was applied to the population in Matrouh and Cairo to calculate the expected number of cases during the summer months adding to it official estimates that 50 percent of those aged 60+ years travel to Matrouh in summer for vacation, a total of 2019 stroke cases was estimated annually (Table 2) (Fig. 1).

According to estimated numbers within the current model, it was assumed that 22 stroke cases are to occur on a daily basis within the Matrouh governorate so at least 11 beds are needed to achieve a successful stroke pathway without any delays.

Additional stroke services: Matrouh hospitals were not found to be connected to local or regional telestroke services and database registries for stroke cases were not readily available as well. Awareness campaigns on stroke were not properly established nor followed on a routine basis.

Discussion

The current model highlighted strength points and detected some gaps by using the WSO roadmap within the Matrouh governorate. Along with the following content and through a problem-solving analytical approach the current model aimed at dealing with the gaps so as to customize and implement a stroke service based on the WSO roadmap.

Matrouh was a good example of implementing a stroke service as it had the basic hospitals and ambulance services yet it was deficient in stroke units, availability of thrombolysis, trained physicians, code stroke, awareness, telestroke, and database analysis (Table 3).

The current model found 2 out of 7 hospitals within Matrouh governorate namely (El Alamein Typical Hospital and Mersa Matrouh General Hospital) to be approaching the term essential healthcare stroke providers as they had the needed diagnostic capabilities and were located at a distance that made them capable of covering a broad area of the governorate (Fig. 2).

Yet, both hospitals are deficient in dedicated stroke beds. According to the estimated numbers in the current model, a total of 11 beds were needed to serve stroke cases within the governorate.

Another gap found in the current model is the deficiency of neuroscience specialty within Matrouh. According to the World Health Organization (WHO), neurology atlas low-income countries have 0.03 neurologists per 100,000 population while low-middle-income countries have 0.13 [19].

Based on Kissani and colleagues; neurologists in Egypt up to 2020 were 3108 [13] and in another study conducted by Roushdy and colleagues in 2022 neurologists were 4500 this makes the neurology specialty not scarce in Egypt [20] with 4.31 neurologists per 100,000 population [21].

The main obstacle is the inequality in the distribution of branches of medicine including neurology along different governorates, most of the specialties are concentrated in Cairo and major cities. Another important obstacle is the failure to retain physicians within Egypt, most physicians find salaries unsatisfactory, suffer from verbal abuse and physical assaults, and do not have a proper job description with an overall dissatisfaction [22–24].

So, one important goal is to improve salary and working conditions to retain specialists more generally [24], reallocating trainees/neurologists during summer to help deliver the service at the beginning and also to offer training to local staff [25], and improving stroke knowledge of the teams that work on the ground and training them on the different major stroke scales to implement in-hospital acute stroke pathway [26–28].

According to the WSO roadmap, the first step in stroke management is recognition of stroke and calling for help at healthcare services [4]. For such a step to occur raising

Table 3 The current model tackled gaps and their solution within Matrouh and how common is it within other LMICs

The gap	The solution	Commonality
Seasonal summer migration	- Reallocating trainees/neurologists during the summer months	Some LMICs have population densities in some regions with few doctors and hospitals [12, 13]
Rising population density	- Increasing the number of hospitals, - Improving hospitals' status to be turned into essential stroke service providers and later on into advanced ones	Population density is on the rise along different LMICs
Absence of official data about stroke estimates	- Obtaining the closest data based on demographics - Activating database systems	Some LMICs might still not provide official data
Shortage of trained physicians on stroke	- Improving salary and working conditions to retain specialists more generally - Reallocating trainees/neurologists during summer—to help deliver the service at the beginning and also to offer training to local staff - Improve Stroke knowledge of the teams that work on the ground and training them on the different major stroke scales	Many LMICs face a shortage of neurologists [12, 13]
Absence of stroke units	- Turning the closest infrastructural equipped hospitals into hospitals with stroke units taking into consideration the population density they are to serve so as to properly calculate needed beds based on turned bed cycle and estimated stroke cases	Stroke units are not common in many LMICs with many countries dealing with stroke in general hospitals [20]
Presence of ambulance services yet, the absence of code stroke	- Training EMS on proper assessment and identification of stroke signs within patients through the use of common pre-hospital stroke scales	Many LMICs have no properly designed approach to deal with stroke including code stroke [20]
Unavailability of thrombolysis	- Thrombolysis is endorsed in Egypt yet not equally distributed throughout the entire country - Delivering thrombolytics to assigned hospitals	Many LMICs still do not have thrombolytics [20]
Making use of telestroke	- Telestroke is present in a single center in Egypt—Ain Shams University Hospital and its virtual hospital - Improving communication infrastructures will make telestroke accessible	Many LMICs are deficient in telestroke [20]
Absence of proper stroke awareness	- Translating the Angels Heroes initiative to Egyptian Arabic and delivering its materials to school children	Awareness of stroke is still low in many countries worldwide [20]
Absence of stroke database	- SITS and RESQ are already used in different Egyptian stroke units – training local staff to apply them within targeted hospitals of Matrouh	Many LMICs do not have stroke database monitoring [20]

LMICs: low- to middle-income countries, EMS: emergency medical services, SITS: safe implementation of treatments in stroke, RESQ: registry of stroke care quality

awareness and linking patients and their caregivers to EMS is a must. Despite code stroke is still not active in Egypt. Yet, it is mandatory for any successful stroke service as it eventually reduces onset to door which reflects on onset to needle time [29, 30].

Matrouh was found to have 60 ambulance units so activating code stroke is reachable. By activating code stroke patients who usually seek private transportation to reach hospitals will find a more professional way that can minimize any potential delay from symptom onset to hospital admission [31].

According to Saini and colleagues in 2016; 13.7 million new stroke cases were encountered globally with approximately 87% ischemic strokes yet less than 5% received thrombolysis [32].

The low thrombolysis rate could be partially attributed to non-eligibility yet it reflects more the failure of the utilization of thrombolytics which could be a result of a lack of awareness about time is brain concept and the face, arm, speech, and time (FAST) criteria.

Raising awareness is a crucial aspect to consider in any stroke service implementation plan. The Angels

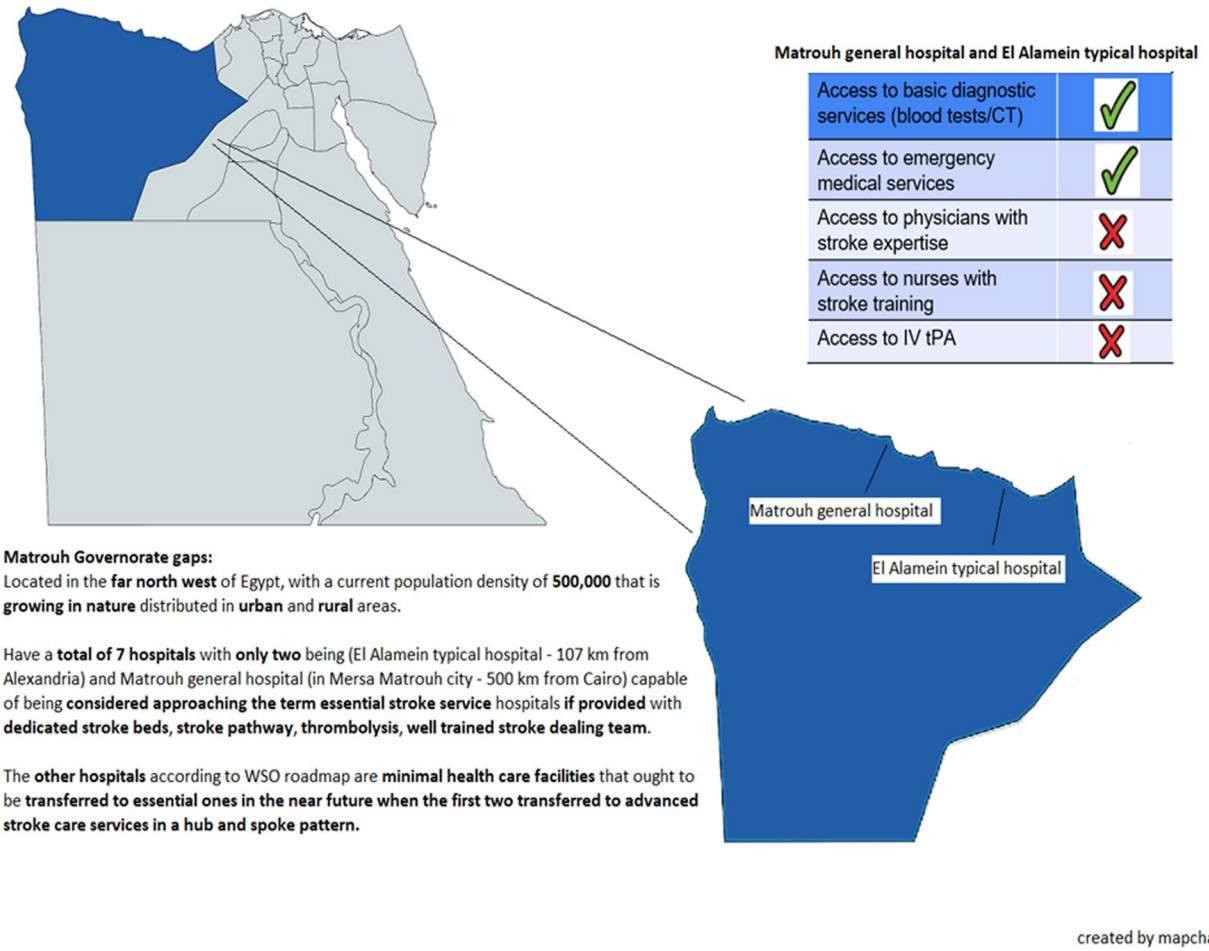

Fig. 2 Matrouh governorate gaps

Initiative, together with the WSO, has introduced the FAST Angels Heroes Initiative which aims at increasing public awareness in general and increasing the awareness of stroke precisely in the young age group within schools [33] making use of such an initiative will be of great value in the situation of Matrouh and in any similar condition where grandchildren are left with grandparents for a proportion of the time in summer season.

Translation of FAST Heroes' Western names to Arabic ones that reflect the cultural background of Egypt and Arabic-speaking countries so as to achieve brain imaging for such heroes and for the FAST criteria along with school children could increase stroke awareness in the region.

The translated material could be presented to school children in their classrooms through a combined campaign held by the stroke chapter within the Egyptian Society of Neurology, Neurosurgery, and Psychiatry which is the main umbrella of Neurologists along entire Egypt and the MOH as well as the Ministry of Education.

Thrombolysis is a must in any successful stroke service implementation. In Egypt, thrombolysis, as well as thrombectomy, are totally endorsed by the government [14]. Yet, this is not the case in most developing countries [20]. rtPA ought to be obtainable for any hospital to be considered an essential healthcare stroke provider and to be called a stroke unit this could be achieved through advocacy with the aid of WSO as was done in Latin America [34].

The funds for higher transportation costs due to the unavailability of stroke units and reduced thrombolysis rates leading to higher lifelong costs can be translated into mobilizing rtPA in the chosen hospitals and building a stroke unit from existing basic resources.

Telestroke was first introduced in 1999, it aims at providing stroke expertise to hospitals that lack physicians well-trained in dealing with stroke. In our model and until solving the problem of neurologist allocation and other specialties training, telestroke will be of reasonable value [35]. Since thrombolysis is of great value in stroke

recovery, yet, it ought to be administered by trained and qualified physicians to avoid any possible adverse effects. Telestroke provides an opportunity for inexperienced clinicians to be supported through assessment, decision-making, and follow-up and has been shown to improve outcomes and reduce the length of stay within hospitals [35].

In Egypt, telemedicine and telestroke units are newly introduced with the telemedicine unit at Ain Shams University Hospitals and the treat and teach initiative of Ain Shams Virtual Hospital [36–39].

The implementation of a telemedicine unit in stroke management can be realized through either a distributed model or a hub and spoke model. In both cases, the patient can be remotely assessed, and decisions regarding intravenous thrombolysis can be made [35].

In situations where a patient requires further management as intervention through thrombectomy or coiling procedures, the patient could be transferred to the nearest hospital with such capabilities which would be located in Alexandria in case of patients within Matrouh general hospital coverage area (245 km from Alexandria rather than 500 km from Cairo). As for patients within El Alamein coverage area (107 km from Alexandria or 261 km from Cairo), it is possible to be transferred to either Alexandria or Cairo based on availability and proper coordination.

It is preferable that patients with suspected large vessel occlusion (LVO) that are candidates for thrombectomy be transferred to El Alamein typical hospital for drip and then shipped to the nearest center, besides El Alamein typical hospital is equipped with an Angio suite so if reallocation of trained interventional neurologists took place then by the time El Alamein typical hospital could be the center providing advanced stroke therapies for the entire north coast of Matrouh governorate and this will save the time of patient's transfer for a distance that might extend for 2 h.

Suspicion of LVO requires training of EMS on the NIHSS or using a pre-hospital stroke scale as well as raising the awareness of the targeted population about the major signs of stroke which is provided through the Angels FAST Heroes initiative [35].

Once establishing a stroke unit, the model recommends self-monitoring with a database and documentation of cases presented to the two chosen hospitals with the use of quality assessment registries that are approved worldwide and already being used in different stroke units in Egypt as the safe implementation of treatments in stroke (SITS) or the Stroke care quality registry (RESQ) so as to follow up any drawbacks in the stroke implementation service with self-monitoring and self-correction [14].

Once stroke recognition takes place and acute management is provided the inpatient care step begins which includes searching for an etiological diagnosis of stroke, rehabilitation, and early mobilization [4].

Rehabilitation and early mobilization although not highlighted in the current model yet, it is present along the entire 7 hospitals of the governorate. Yet, the current model analysis found only 7 physical medicine and 16 physical therapists serving within the governorate so it is recommended to increase this number in the future government plans and this highlights that for a successful stroke service not only neurologists are needed but multidisciplinary team is needed as well [34, 35].

Comprehensive stroke management extends beyond acute management to include the identification of risk factors and secondary prevention intervention. Services addressing stroke recurrence risk are well established in Egypt where there is access to internal medicine and cardiology clinics; medications management of hypertension, diabetes, dyslipidemia; and antiplatelet and anticoagulant therapies. The two chosen hospitals in our study have these secondary prevention capabilities. This is not the case in other developing countries with a corrective plan needed to achieve availability of screening for modifiable vascular risk factors and endorsement of related medications [20].

For successful stroke management, the WSO roadmap identified the importance of dysphagia screening and this is achievable through different approaches from the very simple drinking water test to the more accurate laryngoscope assessment [4]. Initiating dysphagia screening for all stroke patients reduces hospital stays and aids in the bed turnover cycle as it reduces the risk of aspiration pneumonia and other related complications [20].

Community reintegration and recovery is one of the important points that are recommended in the roadmap and still deficient in most developing countries including Egypt and this is achievable only through an entire country development system approach with cooperation between governmental and non-governmental sectors of the community [20, 35].

The current study has certain limitations that should be acknowledged. Firstly, it remains a theoretical framework and has not yet been implemented in real-world settings. Therefore, its actual feasibility or effectiveness cannot be fully assessed without practical application, second there were not any epidemiological studies on stroke incidence in Matrouh so the current model used the nearest suitable example that was conducted in the New Valley governorate to estimate the number of stroke cases that to be encountered annually in Matrouh, third the liability of population density variability along the year yet this condition is present along different countries with

touristic backgrounds and is of value to be highlighted and analyzed. Despite these limitations, the study possesses several strengths. It offers a unique approach by transforming the algorithms of the WSO roadmap into a stepwise analytical study. This allows for a comprehensive evaluation of stroke service implementation within a specific context. The choice of Matrouh governorate as a study site provides a representative example of a region with a combination of rural and urban areas, bordering characteristics, and a population that is increasing in nature. By focusing on a realistic problem-solving situation, the study offers practical insights and potential solutions for stroke service implementation.

Conclusions

Mapping stroke infrastructure allows for identifying potential gaps to optimize the potential for implementation of stroke service.

Abbreviations

WSO	World Stroke Organization
EMS	Emergency medical services
LMICs	Low- and middle-income countries
rtPA	Recombinant tissue plasminogen activator
MOH	Ministry of Health
CAPMAS	Central Agency for Public Mobilization and Statistics
CT	Computed tomography
MRI	Magnetic resonance imaging
WHO	World Health Organization
FAST	Face arm speech and time
LVO	Large vessel occlusion
SITS	Safe implementation treatment for stroke
RESQ	Stroke care quality registry

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Author contributions

Authors have read and approved the manuscript. TR: conceptualization, collection of the scientific data, collection of on-ground data, applying WSO road map on the model, writing, and preparation of original draft, writing, and editing. MA: conceptualization, applying WSO road map on the model, editing of original draft, revising draft, analysis. RL, TU, MGM: conceptualization, collection of scientific data, applying WSO road map on the model, revising draft, analysis. ER: conceptualization, collection of scientific data, analysis and applying WSO road map on the model, revising draft. LL: conceptualization, collection of scientific data, applying WSO road map on the model, statistical part, revising draft, writing, and editing.

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Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

None.

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References

1. Feigin VL, Brainin M, Norrving B, Martins S, Sacco RL, Hacke W, et al. World stroke organization (WSO): global stroke fact sheet 2022. Int J Stroke. 2022;17(1):18–29. https://doi.org/10.1177/17474930211065917.
2. Rodgers H. Stroke. Handb Clin Neurol. 2013;110:427–33. https://doi.org/10.1016/B978-0-444-52901-5.00036-8.
3. Strilciuc S, Grad DA, Radu C, Chira D, Stan A, Ungureanu M, Gheorghe A, Muresanu FD. The economic burden of stroke: a systematic review of cost of illness studies. J Med Life. 2021;14(5):606–19. https://doi.org/10.25122/jml-2021-0361.
4. Lindsay P, Furie KL, Davis SM, Donnan GA, Norrving B. World Stroke Organization global stroke services guidelines and action plan. Int J Stroke. 2014;9(SA100):4–13. https://doi.org/10.1111/ijs.12371.
5. Green TL, McNair ND, Hinkle JL, Middleton S, Miller ET, Perrin S, et al. Care of the patient with acute ischemic stroke (post hyperacute and prehospital discharge): update to 2009 comprehensive nursing care scientific statement: a scientific statement from the American heart association. Stroke. 2021;52(5):179–97. https://doi.org/10.1161/STR.0000000000000357.
6. Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, et al. 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):344–418. https://doi.org/10.1161/STR.0000000000000211.
7. European Stroke Organisation (ESO) Executive Committee; ESO Writing Committee. Guidelines for management of ischaemic stroke and transient ischaemic attack 2008. Cerebrovasc Dis. 2008;25(5):457–507. https://doi.org/10.1159/000131083.
8. Berge E, Whiteley W, Audebert H, De Marchis GM, Fonseca AC, Padiglioni C, et al. European Stroke Organisation (ESO) guidelines on intravenous thrombolysis for acute ischaemic stroke. Eur Stroke J. 2021;6(1):I–LXII. https://doi.org/10.1177/2396987321989865.
9. Navi BB, Audebert HJ, Alexandrov AW, Cadilhac DA, Grotta JC, PRESTO (Prehospital Stroke Treatment Organization) Writing Group. Mobile stroke units: evidence, gaps, and next steps. Stroke. 2022;53(6):2103–13. https://doi.org/10.1161/STROKEAHA.121.037376.
10. Kalkonde YV, Alladi S, Kaul S, Hachinski V. Stroke prevention strategies in the developing world. Stroke. 2018;49(12):3092–7. https://doi.org/10.1161/STROKEAHA.118.017384.
11. Bergen DC, World Federation of Neurology Task Force on Neurological Services. Training and distribution of neurologists worldwide. J Neurol Sci. 2002;198(1–2):3–7. https://doi.org/10.1016/s0022-510x(02)00071-0.
12. World health organization, the global health observatory. Number of neurologists (per 100,000) website: number of neurologists (per 100,000). https://www.who.int/. Accessed 18 June 2023.
13. Kissani N, Liqali L, Hakimi K, Mugumbate J, Daniel GM, Ibrahim EAA, et al. Why does Africa have the lowest number of neurologists and how to

cover the Gap? J Neurol Sci. 2022;434: 120119. https://doi.org/10.1016/j.jns.2021.120119.
14. Aref H, Zakaria M, Shokri H, Roushdy T, El Basiouny A, El Nahas N. Changing the landscape of stroke in Egypt. Cerebrovasc Dis Extra. 2021;11(3):155–9. https://doi.org/10.1159/000521271.
15. Central agency for public mobilization and statistics. http://www.capmas.gov.eg/. Accessed 18 June 2023.
16. Ministry of planning and economic development official site, citizen investment plan 2022/2023. http://mped.gov.eg/.
17. Central Agency for Public Mobilization and Statistics: Annual bulletin of health services and treatment at state's expense at home and abroad 2019. Feb 2021 http://www.capmas.gov.eg/. Accessed 18 June 2023.
18. Farghaly WM, El-Tallawy HN, Shehata GA, Rageh TA, Abdel-Hakeem NM, Elhamed MA, et al. Epidemiology of nonfatal stroke and transient ischemic attack in Al-Kharga District, New Valley, Egypt. Neuropsychiatr Dis Treat. 2013;9:1785–90. https://doi.org/10.2147/NDT.S48322.
19. World Health Organization. Atlas: country resources for neurological disorders. 2nd ed. Geneva: World Health Organization; 2017.
20. Roushdy T, Aref H, Kesraoui S, Temgoua M, Nono KP, Gebrewold MA, et al. Stroke services in Africa: what is there and what is needed. Int J Stroke. 2022;17(9):972–82. https://doi.org/10.1177/17474930211066416.
21. Aref H, El Nahas N, Alrukn SA, Khan M, Kesraoui S, Alnidawi F, et al. Stroke services in MENA: what is there and what is needed. PLoS ONE. 2023;18(7): e0288030. https://doi.org/10.1371/journal.pone.0288030.
22. Abdul Rahman A, Abdel Halim A, Allam M, Meky F. Low job satisfaction among physicians in Egypt. TAF Prev Med Bull. 2008;7:91–6.
23. Kamal Elden N, Ibrahim H, Wahby G. Improving health system in Egypt: perspectives of physicians. Egypt J Comm Med. 2016;34(1):45.
24. Fasseeh A, ElEzbawy B, Adly W, ElShahawy R, George M, Abaza S, et al. Healthcare financing in Egypt: a systematic literature review. J Egypt Public Health Assoc. 2022;97(1):1. https://doi.org/10.1186/s42506-021-00089-8.
25. Albart SA, Yusof Khan AHK, Abdul Rashid A, Wan Zaidi WA, Bidin MZ, Looi I, et al. Knowledge of acute stroke management and the predictors among Malaysian healthcare professionals. PeerJ. 2022;10: e13310. https://doi.org/10.7717/peerj.13310.
26. Lyden P. Using the national institutes of health stroke scale: a cautionary tale. Stroke. 2017;48(2):513–9. https://doi.org/10.1161/STROKEAHA.116.015434.
27. Dusenbury W, Alexandrov AW. Clinical localization of stroke. Crit Care Nurs Clin North Am. 2020;32(1):1–19. https://doi.org/10.1016/j.cnc.2019.10.001.
28. Roushdy T, Mikhail NW, Abdelaziz SR. NIHSS is deficient in acute stroke presenting with cortical deafness; clinical skills remain the backbone: a case report. Egypt J Neurol Psychiatr Neurosurg. 2023;59(1):38. https://doi.org/10.1186/s41983-023-00645-3.
29. Vanhoucke J, Hemelsoet D, Achten E, De Herdt V, Acou M, Vereecke E, et al. Impact of a code stroke protocol on the door-to-needle time for IV thrombolysis: a feasibility study. Acta Clin Belg. 2020;75(4):267–74. https://doi.org/10.1080/17843286.2019.1607991.
30. Tejada Meza H, Saldaña Inda I, Serrano Ponz M, Ara JR, Marta Moreno J, en representación del Grupo de Atención al Proceso Ictus en el Sector II-Zaragoza. Impact of a series of measures for optimisation hospital code stroke care on door-to-needle times. Neurologia (Engl Ed). 2023;38(3):141–9. https://doi.org/10.1016/j.nrleng.2020.07.023.
31. Aref HM, Shokri H, Roushdy TM, Fathalla F, El Nahas NM. Pre-hospital causes for delayed arrival in acute ischemic stroke before and during the COVID-19 pandemic: a study at two stroke centers in Egypt. PLoS ONE. 2021;16(7): e0254228. https://doi.org/10.1371/journal.pone.0254228.
32. Saini V, Guada L, Yavagal DR. Global epidemiology of stroke and access to acute ischemic stroke interventions. Neurology. 2021;97:6–16. https://doi.org/10.1212/WNL.0000000000012781.
33. Tsakpounidou K, van der Merwe J, Klinke ME, Webb C, Ouriques Martins SC, Proios H. FAST heroes: results of cross-country implementation of a global school-based stroke education campaign. Front Public Health. 2022;10: 849023. https://doi.org/10.3389/fpubh.2022.849023.
34. Martins SCO, Lavados P, Secchi TL, Brainin M, Ameriso S, Gongora-Rivera F, et al. Fighting against stroke in Latin America: a joint effort of medical professional societies and governments. Front Neurol. 2021;1(12): 743732. https://doi.org/10.3389/fneur.2021.743732.
35. Sarzyńska-Długosz I. An optimal model of long-term post-stroke care. Front Neurol. 2023;14:1129516. https://doi.org/10.3389/fneur.2023.1129516.
36. Wechsler LR, Demaerschalk BM, Schwamm LH, Adeoye OM, Audebert HJ, Fanale CV, et al. Telemedicine quality and outcomes in stroke: a scientific statement for healthcare professionals from the American heart association/American stroke association. Stroke. 2017;48(1):3–25. https://doi.org/10.1161/STR.0000000000000114.
37. Wahba H, Emara T, Elbokl A. The Egyptian-African telemedicine network: the treat and teach comprehensive model. In: Hemanth DJ, Valentina EB, editors. Telemedicine technologies. London: Academic Press; 2019. p. 183–92. https://doi.org/10.1016/B978-0-12-816948-3.00012-X.
38. Alboraie M, Allam MA, Youssef N, Abdalgaber M, El-Raey F, Abdeen N, et al. Knowledge, applicability, and barriers of telemedicine in Egypt: a national survey. Int J Telemed Appl. 2021;9:5565652. https://doi.org/10.1155/2021/5565652.
39. Shouman S, Emara T, Saber HG, Allam MF. Awareness and attitude of primary healthcare patients towards telehealth in Cairo, Egypt. Curr Med Res Opin. 2022;38(6):993–8. https://doi.org/10.1080/03007995.2022.2065141.

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