Mobile medical applications in neurology

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Summary

Smartphone or mobile applications (apps) are increasingly used in clinical practice. Apps have evolved from electronic pocket references to interactive utilities, ranging from dynamic visual references, interactive and analytic clinical tools, remote desktops, and scheduling and communication platforms. Additionally, apps designed for patient monitoring, advising, data collection, and documentation are useful for clinicians, researchers, and patients. This report aims to provide an introduction to several valuable mobile apps for neurologists and students of neurology.

Physicians increasingly use smartphone or mobile applications (apps) in daily practice. What began as electronic pocket references have developed into interactive utilities, ranging from dynamic visual references to analytic clinical tools, remote desktops, and scheduling and communication platforms. While initial efforts targeted clinicians directly, newer apps target both clinicians and patients, in an effort to improve monitoring, advising, data collection, and documentation.

Apps may dramatically increase the ease and speed at which neurologists access, synthesize, and act on clinical data and reference information by bringing information to the neurologist effectively. In essence, this translates into holding much more information, but without the burden of physically carrying actual texts or changing locations to gain access to information. Further, touchscreen platforms may offer views, manipulations, and visual representations of material that could not be offered previously.

As of April 2012, there are more than 13,600 health and fitness apps available on the iPhone alone,¹ many of which are relevant to neurologists and patients with neurologic conditions. Neurologic apps span general neurology, neurologic subspecialties, neuroradiology, and neurosurgery. Apps have also been used and reviewed in other specialties, including primary care, infectious disease, gastroenterology, and orthopedics.^{2–6}

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Should neurologists care about apps? Technological and information systems advances have led to an unprecedented amount of clinical information available at a fingertip's distance. As such, clinicians have embraced electronic clinical applications, datasets, and medical records to manage the influx of information. Apps increasingly offer better ways to access and manage this information while improving communication with colleagues and patients.

A comprehensive survey of all neurology apps is beyond the scope of this review, but this report aims to provide an introduction to several valuable mobile neurology apps. It focuses on apps on the iOS platform (used by iPhone and iPad), and notes when available for the Android platform (tables 1 and 2). For this report, apps were found by the following means: 1) iTunes and Android store searches for "neurology," "neurologic," "neurological," "neuroradiology," "radiology," "neurosurgery," "neuro exam," "neurology exam," "neurologic exam," "brain," "neuroanatomy," "epilepsy," "seizure," "multiple sclerosis," "Parkinson," "stroke," "headache," "nerve," "neuromuscular," and "CME," 2) review of health care mobile application rating reports; and 3) survey of Partners Neurology residents.

Apps are categorized into 2 major categories in this article: "Doctor" (table 1) and "Patient Care" (table 2). The Doctor apps are further categorized as follows: reference, academic, communication, and classroom. The Patient Care apps are categorized as follows: localization and examination, documentation-administrative, monitoring-analytics, and advising-teaching. The apps reported in this article (listed in tables 1 and 2) are not ranked or graded, but reflect a sample of apps available to the practicing neurologist.

Doctor

References Reference apps are the most common apps relevant to neurologists. Similar to textbooks, these apps serve as reference material and take the form of textbooks. Skyscape offers The Manual of Neurologic Therapeutics, Evidence-Based Medicine Guidelines–Neurology, Merritt's Neurology Handbook, 5-Minute Neurology Consult, and Washington Manual Neurology Survival Guide. Medscape also has extensive reference material on neurologic conditions. Pocket card–like apps allow quick referencing visual and textual information for common neurologic conditions by Neurology Figures and i-Pocketcards: Neurology Suite, Multiple Sclerosis Diagnosis & Management, and The Strokes. Some reference apps replicate Web-based content platforms into a mobile version, allowing for easy updates of the neurologic information: UpToDate provides evidence-based, peer-reviewed articles on myriad neurologic subjects.

Some apps focus on developing differential diagnoses using specific symptoms or signs. These include First Consult and Diagnosaurus.

Although geared primarily for neurosurgeons, the Neurosurgery Survival Guide is of general use, particularly for neurosurgical and neurologic intensive care unit management of acute disease. It provides descriptions of neurosurgical procedures and protocols in the evaluation of neurologic patients with surgical and nonsurgical disease. It also includes many of the references and scales included in previously mentioned apps.

Table 1 "Doctor" medical applications

Category	Description	Application name	iPad	Price, USD	iPhone	Price, USD	Android	Price, USD
References	Textbook	Manual of Neurologic Therapeutics	Y	72.99	Y	72.99	Y	72.99
	Textbook	Evidence-Based Medicine Guidelines-Neurology	Y	39.99	Y	39.99	Y	39.99
	Textbook	Meritt's Neurology Handbook	Y	77.5	Y	77.5	Y	77.5
	Textbook	5-Minute Neurology Consult	Y	94.99	Y	94.99	Y	92.95
	Textbook	Washington Manual Neurology Survival Guide	Y	46.5	Y	46.5	Y	46.5
	Textbook	Neurology Figures	N	N/A	N	N/A	Y	2.48
	Textbook	i-Pocketcards	Y	Free-19.99	Y	Free-19.99	Y	Free-4.99
	Textbook, Meds, CME	Medscape	Y	Free	Y	Free	Y	Free
	Textbook	UpToDate	Y	Fees	Y	Fees	Y	Fees
	DDx	First Consult	Y	Fees	Y	Fees	N	
	DDx	Diagnosaurus	Y	1.99	Y	1.99	Y	1.99
	Neurosurgery	Neurosurgery Survival Guide	N		Y	7.99	Y	7.99
	Scales, scores	Calculate (QxMD)	Y	Free	Y	Free	Y	Free
	Scales, scores	Mediquations	Y	4.99	Y	4.99	Y	4.99
	Scales, scores	Neuro toolkit	Y	2.99	Y	2.99	N	
	Scales, scores	NeuroMind	Y	Free	Y	Free	Y	Free
	Anatomy	Brain Tutor	Y	1.99	N	Free	N	
	Anatomy	3D Brain	Y	Free	Y	Free	Y	Free
	Anatomy	iSurfBrainView	Y	Free	Y	Free	N	
	Anatomy	Brain & Nervous System Pro III: NOVA Series Collection	Y	19.99	N		N	
	Anatomy	eAnatomy	Y	0-69.99	Y	0-69.99	Y	0-69.99
	Anatomy	Brain MRI Atlas/HD	Y	Free-9.99	N		N	
	Anatomy	NeuroRad	Y	19.99	Y	9.99	N	
	Anatomy	3D Brain & Nervous System Anatomy	Y	9.99	N		N	
	Anatomy	3D Muscle Premium 2	Y	19.99	N		N	
	Anatomy	Netter's Neuroscience Flashcards	Y	39.99	N		N	
	Anatomy	Netter's Concise Radiologic Anatomy	Y	39.99	N		N	
	Anatomy	Netter's Advanced Head & Neck Flash Cards	Y	39.99	N		N	
	Anatomy	Imaging Atlas of Human Anatomy	Y	59.99	N		Y	
	Anatomy	Sylvius MR: Atlas of the Human Brain	Y	14.99	N		N	
	Anatomy	Thieme: Atlas of Anatomy	Y	79.99	N		N	

Continued

Table 1 Continued

Category	Description	Application name	iPad	Price, USD	iPhone	Price, USD	Android	Price, USD
	Anatomy	Essentials of Clinical Anatomy By Inking	Y	9.99–64.99	N		N	
	Meds	ePocrates	N		Y	Free	Y	Free
	Labs	ARUP Consult	Y	Free	Y	Free	Y	Free
Academic	Journal	Neurology®	Y	Fees	N	Fees	N	
	Journal	Neurology®: Clinical Practice	Y	Fees	N	Fees	N	
	Journal	Neurology®: Continuum	Y	Fees	N	Fees	Y	Fees
	Journal	Lancet (Neurology)	Y	Fees	N	Fees	N	
	Journal	Stroke	Y	Fees	N	Fees	N	
	Journal	Epilepsia	Y	Fees	Y	Fees	Y	Fees
	Journal	Annals of Neurology	Y	Fees	Y	Fees	N	
	Journal review	Journal Watch Neurology	Y	59.99	Y	59.99	Y	59.99
	EBM	DynaMed	N		Y	Free	Y	Free
	Writing-research	PubGet	Y	Fees	N		N	
	Writing-research	Papers	Y	14.99	Y	14.99	N	
	Writing-research	GoodReader	Y	4.99	Y	4.99	N	
Communication	Curbside	Sermo	Y	Free	Y	Free	N	Free
	Curbside	QuantiaMD	Y	Free	Y	Free	Y	Free
	Curbside-phonebook	Doximity	Y	Free	Y	Free	Y	Free
Classroom	CME	Living Medical Textbook	Y	Free	Y	Free	N	
	CME	MyCME	Y	Free	Y	Free	Y	Free
	CME	OpenCME	Y	Free	Y	Free	N	
	CME	ePocrates CME	N		Y	Free	N	
	Boards	Neurology and RITE questions	Y	Free–5.99	Y	Free–5.99	N	
	Boards	Neuro Board Review	N		Y	29.99–49.99	N	

A variety of apps provide scales, scores, and formulas. Examples include the modified Rankin Stroke Scale score, the NIH Stroke Scale score, and intraparenchymal hemorrhage volume on CT. Apps of this nature include Calculate (QxMD), MediQuations, Medscape, Neuro Toolkit, and NeuroMind.

Handheld touchscreens have led to the development of educational tools, which can be informative to clinicians, trainees, and patients. Many offer highly useful views of surface and cross-sectional anatomy: Brain Tutor (figure 1), 3D Brain, iSurfBrainView, and Brain & Nervous System Pro III: NOVA Series Collection.

Several advanced apps focus on anatomy, but with a radiologic slant. e-Anatomy (figure 2) and other similar apps (BrainMRI and Brain MRI Atlas) allow the user to scroll through multiplanar MRI sections by touchscreen controls. A similar app, NeuroRad (figure 3), also provides various means to view vessels and vascular territories. They allow the user to

Table 2 "Patient care" medical applications

Category	Description	Application name	iPad	Price, USD	iPhone	Price, USD	Android	Price, USD
Localization-examination	Neuromuscular	Nerve whiz	N		Y	Free	Y	Free
	Neuro-ophthalmology/otology	aVOR	Y		Y	Free	N	
	Neuro-ophthalmology	Eye Handbook	N		Y	Free	Y	Free
Documentation-administrative	Patient log/notes	Clinical Log	N		Y	Free-19.99	N	
	Patient log/notes	MyPatientLogs	N		Y	1.99	Y	2.99
	Billing	IDC9_HCPCS	Y	Free	Y	Free	N	
	Billing	ICD9 Consult 2012 Free	Y	Free	Y	Free	N	
Monitoring-analytics	Headache log	iHeadache	N		Y	4.99	N	
	Stroke	Stroke track	N		Y	Free	N	
	Angiography	Angio Suite-Neuro Ed.	N		Y	Free	N	
Advising-teaching	Brain diseases	FINR Brain Atlas	Y	1.99	Y	1.99	N	

selectively label specific structures, such as sulci, gyri, ventricles, cisterns, brainstem, or vessels. 3D Brain & Nervous System Anatomy and 3D Muscular Premium Anatomy allow users to dynamically explore 3D models of the brain, nerves, and muscles. The format is highly flexible, in that structures of interest can be isolated and viewed from any angle, which is particularly useful in understanding the relationships between various structures.

Figure 1 Brain Tutor

Reproduced with permission from Brain Innovation.

Figure 2 e-Anatomy

Reproduced with permission, e-Anatomy, Micheau A, Hoa D, www.imaaios.com.

A set of apps using the Modality platform (Netter's Neuroscience Flash Cards, Netter's Concise Radiologic Anatomy, Netter's Advanced Head & Neck Flash Cards, Imaging Atlas of Human Anatomy, Sylvius MR: Atlas of the Human Brain, and Thieme: Atlas of Anatomy) provide numerous neuroanatomic plates of drawings and radiology. Inkling has the "Essentials of Clinical Anatomy," which includes an interactive approach to basic neuroanatomy.

ePocrates and Medscape are used to query medications and drug–drug interactions. ARUP Consult allows providers to obtain detailed information on diagnostic tests and testing limitations for specific conditions, such as the Huntington disease mutation tested by Southern blot and PCR analyses.

Academic

Many journals are now available in app form: *Neurology*[®], *Neurology*[®] *Clinical Practice*, *CONTINUUM: Lifelong Learning in Neurology*[®], *Lancet (Neurology)*, *Stroke*, *Epilepsia*, *Annals of Neurology*, and *Journal Watch Neurology*. DynaMed (available on the Skyscape platform) provides clinical summaries for numerous neurologic conditions, many of which are clinical management oriented. Content is linked to research references and guidelines, and thus, serves as quick reference to updated evidence-based guidelines.

PubMed searches the academic literature akin to PubMed, with the benefit of direct links to pdfs within the search outputs. Papers organizes pdfs into folders and libraries. It wirelessly syncs with its correlate computer application, providing access to libraries of pdfs. It also seamlessly creates reference lists for paper writing. GoodReader is another app for pdf viewing.

Communication Sermo and QuantiaMD support large physician communication networks, which facilitate curbside consultation. Sermo's app has built-in mobile photography capture to

Figure 3 NeuroRad

Reproduced with permission from RadLynx LLC.

display patient findings. Doximity has similar utility, but also focuses on physician address and phonebook functionality, getting in touch with colleagues, and increasing practice visibility.

Classroom The continuing medical education (CME) market has also moved into the app environment. Several neurology-specific modules are offered through Living Medical Textbook (Parkinson Disease, Multiple Sclerosis, and MedImage Cases: MS). Medscape, MyCME, OpenCME, and ePocrates CME also have neurology-specific modules on their general CME platforms. Neurology and RITE questions and Neuro Board Review provide sample questions for board preparation.

Patient care

Localization and examination There are also apps to allow better localization of neurologic problems. Nerve Whiz is a simple, rich reference to peripheral nervous system localization and function. aVOR is a dynamic, 3D rotational tool that provides insight into normal and pathologic states of the inner ear. Users can simulate eye movements and control the function of specific semicircular canals to better understand related eye movement abnormalities, including nystagmus.

Eye Handbook has an array of examination tools, including near visual acuity, contrast sensitivity, Ishihara color plates, Amsler grid, penlight functionality, pupil gauge, and an optokinetic nystagmus drum. It also contains an eye atlas with fundus photographs of conditions relevant to neurologists.

Documentation-administrative Medical applications strive to make an impact at the point of care. In some cases, this takes the form of patient logs and documentation. Clinical Log and MyPatientLogs enable the physician to quickly record patient visits and details, which may then be e-mailed as text documents and ultimately copied and pasted into electronic medical records.

ICD9+ HCPCS and ICD9 Consult 2012 are quick searchable references for neurologic ICD-9 codes.

As the design and usability of apps improves, and the demand for more efficient clinical care and easier access to medical knowledge increases, neurologists and their patients will increasingly turn to health care apps on mobile devices.

Monitoring-analytics iHeadache is a headache (and migraine) diary for patients, which allows headache details to be recorded systematically and then messaged as text documents. Details recorded include headache time, duration, severity, associated symptoms, and triggers.

Stroke Track structures queries into fields, which are logged into databases for stroke patients: demographics, NIH Stroke Scale score, predicated outcome, tissue plasminogen activator (tPA) checklist and contraindications, and tPA dose. Similarly, Angio Suite (Neuro Ed.) allows logging of interventional neurology patients, but also provides means for further evaluation of cerebral aneurysms, such as volume calculation and 3D rendering.

Advising-teaching Although many of the previously mentioned reference apps may be useful teaching tools for patients, they may contain excess detail, making them difficult for patients to understand. The FINR Brain Atlas provides various simple 3D rotational superficial and deep brain views as well as specific visual and textual information on various neurologic conditions such as cerebral aneurysm, anoxia, contusion, stroke, and hemorrhage.

Future direction

The apps included in this report may be of use to many neurologists and students of neurology. As apps become better integrated into the clinical encounter, they will increasingly improve patient monitoring and patient care management, and improve communication between providers. Ultimately, apps may be used to record and track condition-specific quality metrics of patient care.

With the explosion of mobile application development and usage, more regulation and transparency of app development will be required, particularly with apps that are directly relevant to patient care. There has been a call for the establishment of metrics to evaluate individual apps,^{2,3} as well as increased transparency and regulation of their development,^{2,4,5,7} akin to regulation of medical devices. In February 2011, the US Food and Drug Administration published draft guidelines stating that some apps constituted “medical devices” and would require regulation.⁸

As the design and usability of apps improves, and the demand for more efficient clinical care and easier access to medical knowledge increases, neurologists and their patients will increasingly turn to health care apps on mobile devices. They will likely have dramatic impact on the practice of documentation, clinical recommendations, patient-to-doctor and doctor-to-doctor communication, scheduling, data evaluation, and clinical decision-making.

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ACKNOWLEDGMENT

The authors thank the Partners Neurology residents for recommending neurology apps for review. They specifically thank Drs. Michael Bowley, Allison Gray, Robert Mallery, Shibani Mukerji, and Kevin Shapiro. They also thank Christine Krueger and Karan Singh for conceptual guidance and copyediting.

STUDY FUNDING

No targeted funding reported.

DISCLOSURES

A. Cohen has received royalties for the publication of mobile applications “The Strokes” and “Brain Hemorrhage and Trauma,” which are i-Pocketcards sets. B. Nahed reports no disclosures. K. Sheth has received royalties for the publication of the mobile application, “Brain Hemorrhage and Trauma,” which is an i-Pocketcards set, and has received research support from the AAN, AHA, Remedy Pharmaceuticals, Brainscope, Inc., and Passano Foundation. He has provided review for medico-legal cases. Go to Neurology.org/cp for full disclosures.

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