

Review Article

Smartphone use in neurosurgery? APP-solutely!

Michael Zaki, Doniel Drazin¹UCLA David Geffen School of Medicine, Los Angeles, California, ¹Department of Neurosurgery, Cedars-Sinai Medical Center, 8700 Beverly Boulevard, West Hollywood, USAE-mail: Michael Zaki - MZaki@mednet.ucla.edu; *Doniel Drazin - DrazinD@cshs.org

*Corresponding author

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Abstract

Background: A number of smartphone medical apps have recently emerged that may be helpful for the neurosurgical patient, practitioner, and trainee. This study aims to review the current neurosurgery-focused apps available for the iPhone, iPad, and Android platforms as of December 2013.

Methods: Two of the most popular smartphone app stores (Apple Store and Android Google Play Store) were surveyed for neurosurgery-focused apps in December 2013. Search results were categorized based on their description page. Data were collected on price, rating, app release date, target audience, and medical professional involvement in app design. A review of the top apps in each category was performed.

Results: The search resulted in 111 unique apps, divided into these 7 categories: 16 (14%) clinical tools, 17 (15%) conference adjunct, 27 (24%) education, 18 (16%) literature, 15 (14%) marketing, 10 (9%) patient information, and 8 (7%) reference. The average cost of paid apps was \$23.06 (range: \$0.99-89.99). Out of the 111 apps, 71 (64%) were free, 48 (43%) had reviews, and 14 (13%) had more than 10 reviews. Seventy-three (66%) apps showed evidence of medical professional involvement. The number of apps being released every year has been increasing since 2009.

Conclusions: There are a number of neurosurgery-themed apps available to all audiences. There was a lack of patient information apps for nonspinal procedures. Most apps did not have enough reviews to evaluate their quality. There was also a lack of oversight to validate the accuracy of medical information provided in these apps.

Key Words: Applications, apps, iPhone, mobile, neurosurgery, smartphone

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INTRODUCTION

Smartphone device use among the general population and by health care providers has been on the rise.^[21] The advanced technology and fascinating hardware available on smartphones allow them to offer various apps that

have proven useful in the medical setting.^[5,13,14,16] These apps also deliver portable and convenient methods of education for clinicians in training and patients.^[6,7] A recent survey found that 60% of physicians access Epocrates (a drug reference app) three times a day while 40% of physicians are recommending apps to

their patients, however, more than half of the physicians surveyed do not know which apps are “good to share.”^[28] To date, the use of smartphone apps has been reviewed in a range of specialties but no comprehensive review of apps available for the field of neurosurgery has been done recently.^[3,4,8,15,17,19,20,22,23,25,29] The aim of this study was to review and categorize contemporary neurosurgery-focused apps that are either helpful in clinical/academic practice or which facilitate education for patients and health care provider trainees on the iPhone, iPad, and Android platforms.

METHODS

Between December 1, 2013 and December 16, 2013, the United States Apple App Store and Android Google Play App Store were surveyed for neurosurgery-related apps using the keywords “neurosurgery,” “neuro surgery,” “neurological surgery,” “neurosurgical,” “neurosurgeon,” “neurological surgeon,” “brain surgery,” “brain surgeon,” “spine surgery,” “spine surgeon,” “spinal surgery,” “back surgery,” “back surgeon,” “craniotomy,” “deep brain stimulation,” and “hydrocephalus.” For each app, data was collected on the number of reviewers, ratings, price, release date, and supported platform based on information in the app summary page provided by the app developer. Data on app release date was only available on the United States Apple App Store. If an app had multiple versions, the ratings and number of reviewers was collected for all versions of the app, not just the most current one. Based on the app summary page and screen shots, apps were grouped into seven categories (clinical tool, conference adjunct, education, literature, patient information, marketing, and reference) and summarized for clarity with results tabulated using Excel 2010 (Microsoft, Redmond, WA, USA). The target audience and medical professional involvement were also evaluated based on the app summary page and screen shots. If the app had a developer website listed in the app summary page, the developer website was visited and used to assist in assigning the app to a category

and evaluating target audience and medical professional involvement. While the search keywords came up with many other apps that were not neurosurgery focused, these were omitted from this review as these were not helpful in clinical and academic practice, patient education, or education of neurosurgery residents and fellows. Non-English apps, games, free “lite” versions of fully functional apps, neurology-specific apps, and orthopedic-specific apps were also excluded. The functionality of the top three apps with five or more reviews based on ratings within each category was reviewed. Applications were not purchased or downloaded.

RESULTS

The search resulted in 78 apps on the iPad, 80 apps on the iPhone, and 51 apps on the Android, after the exclusions. Some apps were replicated on two or three platforms and therefore only 111 unique apps were reviewed. The average cost of the apps was \$23.06 and their prices ranged from free to \$89.99. Of the 111 apps, 71 (64%) were free, 48 (43%) had reviews, and 14 (13%) had more than 10 reviews. Seventy-three (66%) apps showed evidence of medical professional involvement either by a named clinician or organization. The app results are further summarized into categories as shown in Table 1.

Categories

Educational apps were the most represented comprising 24% of the apps reviewed while Patient Information and Reference apps were the least represented at 9% and 7% of the apps reviewed, respectively. The rest of the app categories were relatively equal in representation ranging from 14% to 16%. The breakdown of app categories is shown in Figure 1.

Number of neurosurgery-focused apps released in the Apple App Store each year

Figure 2 outlines the number of neurosurgery-focused apps released in the Apple App Store each year.

Table 1: Summary of app search results

Category	Number of apps in category (%)	Apps with medical professional involvement (%)	Average price	Price range	Number of free apps (%)	Number of apps with reviews (%)	Number of apps with >10 reviews (%)	Average rating (%)	Target audience
Clinical tools	16 (14)	10 (63)	\$19.55	Free-\$49.99	7 (44)	6 (38)	4 (25)	3.75	Clinicians
Conference adjunct	17 (15)	17 (100)	Free	Free	17 (100)	3 (18)	1 (6)	3	Conference attendees
Education	27 (24)	16 (59)	\$11	Free-\$39.99	8 (30)	16 (60)	3 (11)	3	Clinician trainee
Literature	18 (16)	16 (89)	\$34.40	Free-\$67.80	16 (89)	6 (33)	0 (0)	4.2	Clinicians
Marketing	15 (14)	5 (33)	Free	Free	18 (100)	6 (33)	1 (7)	3.75	Clinicians
Patient information	10 (9)	1 (10)	\$31.37	Free-\$89.99	2 (20)	6 (60)	4 (40)	3.9	Patients
Reference	8 (7)	8 (100)	\$18.99	Free-\$74.99	3 (38)	5 (63)	1 (13)	4	Clinicians and trainees
Total	111	73 (66)	\$23.06	Free-\$89.99	71 (64)	48 (43)	14 (13)	3.65	

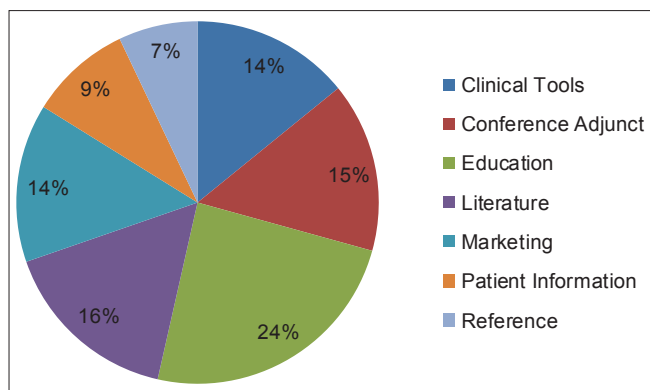


Figure 1: Pie chart for the breakdown of number of apps in each category

Since the graph shows steady increase in the number of apps produced each year, annual review of new apps being released may be warranted.

Clinical tool apps

The search revealed 16 clinical tool apps. This category included five medical calculators (clinical decision support apps, prognosis scores, risk calculators), four apps that assist with placement and maintenance of Deep Brain Stimulation leads, and two apps to measure spinal angles on radiographs. This category also included the following: Thomale Guide App; an app that assists with placement of ventricular catheters, SOAP; an app used to collect outcomes data on patients after spinal procedures, Neurovascular Intervention; an app used to calculate the rate of embolization of cerebral aneurysm, StealthStation AxiEM Station Setup and Workflow Primer; an app that aids in navigation during stereotactic surgery; and Operative Flash Dictations, which provides templates for dictating a neurosurgery operative note. The cost of these apps ranged from free to \$49.99 with seven free apps and only three apps costing more than \$20.00. Only 6 out of 16 apps had reviews and only 4 out of the 16 apps had more than 10 reviews. Average rating for apps with reviews was 3.75 stars. All apps are targeted to a clinician audience except for one app, NeuroRisk (no reviews; \$3.99; iPhone only), which allows patients and clinicians to assess preoperative risk for complications from neurosurgical procedures.

Conference adjunct apps

The search revealed 17 conference adjunct apps. These apps are to be used in conjunction with their respective conferences to provide schedules of talks and more information about speakers and topics to conference attendees. All conference-adjunct apps are available for free and the target audience is conference attendees. The conference-adjunct apps replace the need to print paper brochures and reduce the carbon footprint that is usually associated with literature at such conferences.

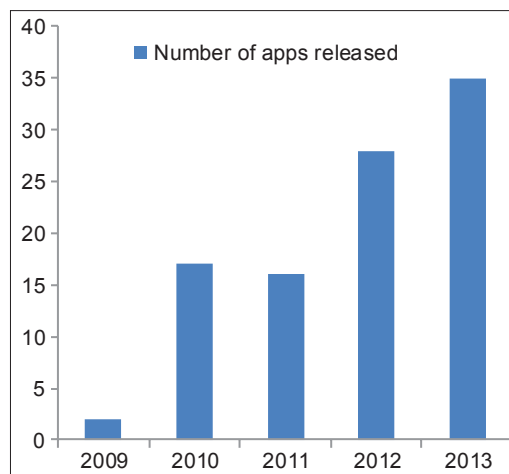


Figure 2: Bar graph of the number of neurosurgery-focused apps released to the Apple App Store each year

Education apps

These are apps that were considered helpful in the education and training of neurosurgery residents, fellows, and mid-level staff. The search revealed 27 apps in that category. This category included six apps that focused on anatomy and basic science, four apps focused on boards, six apps focused on neurosurgery conditions and treatments, five apps on neuroradiology, six apps focused on surgical technique and physical exam. Sixteen out of 27 apps showed evidence of medical professional involvement. The cost of these apps ranged from free to \$39.99 with only eight free apps. The Neuro Board Review app (73 reviews averaging 3 stars; Free; iPad only), an app that provides educational information to the neurosurgery trainee in the form of flashcards and multiple choice questions, was free to install but required payment of \$29.99-49.99 as a subscription fee for each of the 11 topics offered. Average cost of apps with pricing excluding Neuro Board Review was \$11.16. Sixteen out of 27 apps had reviews with only 3 apps having more than 10 reviews. Average rating for apps with reviews was 3 stars. Of note, an innovative app called VCath (one 3 star review; Free; iPad only) allows the neurosurgical trainee to practice placing a ventricular catheter in a simulated setting.^[5]

Literature apps

These apps include journals or blogs/magazines that deliver news and new publications/advancements in the field of neurosurgery. The search revealed 18 apps that fit this category. All the apps are targeted to clinicians and neurosurgeons in training. This category includes 12 journal apps, 2 magazines, and 4 blogs. All of the apps are free except for two, one costing \$1.03 and the other costing \$67.80. Four journal apps of the 16 free apps required in-app purchases ranging from \$14.99 to \$59.99 per journal issue. Only 6 out of 18 apps had reviews with none having over 10 reviews. Average rating for apps with reviews was 4.2 stars.

Marketing apps

These are apps that were created by medical equipment vendors or private practices to promote their businesses. There are 15 apps that fit this category. Eleven out of 15 apps are targeted to clinicians while the other 4 are targeted to patients. All the apps are available for free. All of the apps offer additional information/education relevant to neurosurgery that may be valuable to clinicians or patients. Six of the 15 apps had reviews with only 1 app having more than 10 reviews.

Patient information apps

These are apps that were created exclusively to provide information about neurosurgical procedures to patients. The search revealed 10 apps in this category. The target audience of five apps is patients while the five other apps allow clinicians to prescribe/explain specific information about neurosurgical conditions and procedures to their patients through the app. All the apps focus on the spinal aspect of neurosurgery. Only one app (Virtual Diagnosis Spine) shows evidence of medical professional involvement. Virtual Diagnosis Spine (no reviews; \$4.99; iPhone and iPad) provides the use with a questionnaire that leads to the most likely diagnosis and available treatment options. Only one app (FlipChart Spine) is entirely free and one app (Spine Decide) is free with monthly (\$19.99) or yearly (\$199.99) subscriptions. The rest ranged from \$0.99 to \$89.99 with only four apps being over \$5.00. Six out of 10 apps had reviews with only 4 apps having more than 10 reviews.

Reference apps

This category includes apps that serve as comprehensive guides to topics related to neurosurgery. The search revealed eight apps in this category targeted to clinicians and neurosurgery residents and fellows. Only three of the eight apps are free and the rest range from \$2.99 to \$74.99 with only one app (Current Diagnosis and Treatment Surgery) greater than \$5.00. Current Diagnosis and Treatment Surgery (one review averaging 5 stars; \$74.99; iPhone, iPad, and Android) is an app providing reference information regarding common disease and disorders surgeons are most likely to encounter with a chapter on neurosurgery. Five of the eight apps had reviews with only one app with more than 10 reviews. All the apps showed evidence of medical professional involvement.

Top three apps in each category

The top apps in each category are summarized in Table 2.

The three top apps in the clinical tools category are Neuromind (299 reviews averaging 3 out of 5 stars; Free; Available on iPad, iPhone, and Android), Neuro toolkit (31 reviews, averaging 3.5 stars; \$2.99; iPad and iPhone only), and Cobb Meter (12 reviews averaging 3.5 stars; \$19.99; iPhone and iPad only). Both Neuromind and Neurotoolkit are medical calculators that calculate various risk and prognosis scores while Cobb Meter is a

tool used to measure Cobb angle, kyphosis angle, and sacral slope on vertical spine X-rays.^[13] All three top apps show evidence of medical professional involvement.

There is only one app in conference adjunct category that had enough reviews to meet top three app criteria. This is the AANS Mobile Membership App (13 reviews averaging 3 stars; Free; iPhone only). AANS Mobile Membership App is created by the American Association of Neurological Surgeons and it was the first annual scientific meeting to utilize a fully integrated app in 2010. The app has year-round functions in addition to its functionality as a conference-adjunct app. It provides a newsfeed, past and current articles from Journal of Neurosurgery, a listing of educational resources for the neurosurgeon, and access to an AANS connection, an online social community.

The top three apps in the education category are Neurotrauma (seven reviews averaging 4.4; Free; Android, iPhone, iPad), Neuroslice (109 reviews averaging 4.4; Free; Android Only), and Neuroradiology - Brain (nine reviews averaging 4.8; \$3.99; Android Only). The Neurotrauma app has a book covering several topics involving traumatic brain injury (TBI) and infections with accompanying quiz questions. The Neuroslice app has several coronal, sagittal, and horizontal slices from magnetic resonance imaging (MRI) scans and brain sections to teach brain anatomy. Finally, the neuroradiology-Brain app has a set of clinical cases with multiple choice questions to assist the user in learning how to quickly spot diagnose common classical central nervous system (CNS) presentations. All three top apps had evidence of medical professional involvement.

Three apps tied for third place in the literature category, so the top four apps were reviewed. These apps are Neurocritical Care (five reviews averaging 4.2 stars; Free; iPhone, iPad, and Android), Neurosurgery (seven reviews averaging 3.5 stars; Free w/\$59.99 In-App purchases; iPad and Android), Neurosurgery Blog (seven reviews averaging 5 stars; Free; Android only), Journal of Vascular and Interventional Radiology (seven reviews averaging 3.5 stars; Free w/\$14.99 In-App purchases; iPad only). The Neurocritical Care app is an app for the Neurocritical Care journal bringing the most recent developments, articles and abstracts in all aspects of acute neurological care. The Neurosurgery app is an app published by the Congress of Neurological Surgeons, which allows access to full issues of the monthly Neurosurgery journal and quarterly Operative Neurosurgery journal. The Neurosurgery Blog is an app created by a Brazilian board certified neurosurgeon providing the latest news in the field of neurosurgery. The Journal of Vascular and Interventional Radiology (JVIR) is an app that delivers full issues of the official journal of the Society of Interventional Radiologists.

Table 2: Top 3 Neurosurgical Apps in each category based on customer reviews

App Category App name	Number of reviews	Average rating	Medical professional involvement	Target audience	Price
Clinical tools					
Neuromind	121	4	Yes	Clinician	Free
Neuro toolkit	31	3.5	Yes	Clinician	\$2.99
Cobb meter	12	3.5	Yes	Clinician	\$19.99
Conference adjunct					
AANS mobile membership app	19	3	Yes	Clinician	Free
Education					
Neuroradiology-Brain	9	4.8	Yes	Clinician trainee	\$3.99
Neuroslice	109	4.4	Yes	Clinician trainee	Free
Neurotrauma	7	4.4	Yes	Clinician trainee	Free
Literature					
Neurosurgery	7	3.5	Yes	Clinician	Free W/\$59.99 In-App purchases
Neurosurgery blog	7	5	Yes	Clinician	Free
JVIR: Journal of vascular and interventional radiology	7	3.5	Yes	Clinician	Free W/\$14.99 In-App purchases
Neurocritical care	5	4.2	Yes	Clinician	Free
Marketing					
DePuySynthes	121	4	No	Clinician	Free
SpineCare	9	4.5	Yes	Patient	Free
SI-Lok	5	5	No	Clinician	Free
Patient information					
Spine Decide	196	4	No	Clinician to patient	Free W/In-App purchases
iSpineOperations	5	4.5	No	Clinician to patient	\$89.99
FlipChart Spine	18	4	No	Clinician to patient	Free
Reference					
Neurosurgery survival guide	22	4.5	Yes	Clinician trainee	\$7.99
Neurosurgery: What's the data?	9	5	Yes	Clinician	\$3.99
Helsinki Microneurosurgery Basics and Tricks	5	4.5	Yes	Clinician trainee	Free

The top three apps in the marketing category are DePuySynthes (121 reviews averaging 4 stars; Free; iPad and iPhone only), SpineCare (nine reviews averaging 4.5 stars; Free; iPad and iPhone only), SI-Lok (five reviews averaging 5 stars; Free; iPad only). DePuySynthes is a company that offers products and services for neurosurgery among other specialties. The app offers a breadth of literature to clinicians and patients in regard to the company's products and surgical procedures required for implementation. SI-Lok is a product line offering hydroxyapatite covered screws and cannulated instruments. The app offers information about the products as well as pre-, intra-, and postoperative images. SpineCare is an app advertising a private multi-disciplinary spine medical practice while providing patient information about spine conditions, treatments, physician bios, and patient testimonials.

The top three apps in the patient information category are Spine Decide - Point of Care Patient Education for Health Professionals by Orca Health (196 reviews

averaging 4 stars; Free with \$19.99 monthly or \$199.99 yearly subscriptions; iPhone and iPad only), Flipchart Spine (18 reviews averaging 4 stars; Free; iPad only), and iSpineOperations (five reviews averaging 4.5 stars; \$89.99; iPhone and iPad only). All top three apps showed no evidence of medical professional involvement and were targeted to the clinician to assist in delivering information to the patient. Spine Decide had information in the form of videos that can be prescribed to patients. It also allows the clinician to annotate MRIs, X-rays, or computed tomography (CT) scans of the patient and include them in the digital handouts. Flipchart Spine gives the clinician the ability to annotate and mark images of healthy and diseased spine to explain to the patient the approach to the surgery and possible adverse events. iSpineOperations is a library of images, visualizations, and notes that educate the patients about the common spine procedures.

The top three apps in the reference category are Neurosurgery survival guide (22 reviews averaging 4.5

stars; \$7.99; iPhone and Android only), Neurosurgery: What's the data? (nine reviews averaging 5 stars; \$3.99; iPhone only), and Helsinki Microneurosurgery Basics and Tricks (five reviews averaging 4.5 stars; Free; iPhone and iPad only). Neurosurgery survival guide is an app developed by a neurosurgeon targeted to neurosurgery residents, fellows, medical students, and mid-level practitioners. It aims to provide a quick high yield reference for the clinical knowledge needed to care for neurosurgical patients. This includes things from the neuro exam, to risk calculators, neuroimaging, neuroanatomy, neurosurgery care protocols, neuro critical care, and a section on spine. Neurosurgery: What's the data? is like uptodate.com except it is specific for neurosurgery. Neurosurgery-related literature is reviewed and presented in an easily accessible format. It is also targeted to all medical professional involved in the care of neurosurgical patients. The Helsinki Microneurosurgery Basics and Tricks is a book written by a neurosurgeon, which includes intraoperative videos and images about a fellowship in microneurosurgery.

DISCUSSION

Overall, there were only a few quality apps that are helpful to practitioners and patients in the field of neurosurgery based on customer ratings. There were generally more apps on the Apple Store than the Android Google Play Store. Many apps had limited information in the app summary page or were not suited specifically for neurosurgeons. The majority of the apps included in the review were targeted to the practicing neurosurgeon or neurosurgeon in training with very few apps targeted to the patient. Of note, searching the Apple Store also revealed a number of neurosurgery-specific podcasts and books available for download on the iBooks app that may be a convenient alternative source of knowledge for the neurosurgeon in training.

Ratings

A majority of the apps lacked reviews. Lack of reviews may make consumers reluctant to download the apps, especially if apps are not free. Moreover, many apps with fewer than 10 reviews had a biased average rating that can falsely promote an app. To overcome this limitation, Cochrane Reviews lists iMedicalApps.com as a reputable source for reviews on mobile medical applications.^[12] Health care providers such as physicians and pharmacists in addition to medical students provide the reviews on this website. Moreover, a resident member of the American Association of Orthopedic Surgeons has also tried to overcome this problem by creating a website www.TopOrthoApps.com dedicated to reviewing apps relevant to his specialty.^[24] This may be the next step the community of neurosurgeons should take to ensure the identification and spread of valuable neurosurgery-related apps.

Patient education apps

Most of the apps targeted to patient audience were for spinal procedures but there was a lack of apps dedicated to educating the patient about other neurosurgical procedures, risks, and complications. Patient education apps are particularly important because they may help with obtaining consent and set expectations for patients, especially for high risk procedures as seen in neurosurgery.^[27] In order for patients to make important decisions about surgery, they must receive sufficient and valid information, and fully comprehend it. The availability of information in the form of an app makes it more readily accessible than printed material. The apps also offer an additional dimension of interactivity such as videos or simple tests to assess the patient's comprehension of the information provided before proceeding with surgery. If the information provided in the app has been previously validated and/or prescribed by the surgeon, it may allow for more scientific reliability than an Internet search. However, most of these apps had no medical professional involvement, which raises concern about future patient safety issues.

Medical professional involvement and oversight

Authorship disclosure within the app summary page was obscure and highly inconsistent and often made it difficult to assess how much the medical professionals were involved. Additionally, only a handful of apps had academic references as their source of information in the app summary page. The Food and Drug Administration (FDA) also released a document in September 2013 outlining its role in regulating medical apps. According to the guidelines in this document, the FDA will only regulate apps that are accessories to regulated medical devices or apps that through marketing, labeling, and the circumstances surrounding the distribution are promoted by the manufacturer to perform the function of a medical device (physical diagnosis, test result analysis and interpretation, disease treatment, or prevention). Therefore it seems that apps that serve the purpose of general education and patient information may be excluded from being regulated. In addition, lack of transparency in disclosure of medical professional involvement and lack of referencing peer-reviewed scientific sources in these apps may prove to be problematic.^[1,10,26] As an example, a recent study discovered significant differences in the outcomes of opioid conversion medical apps with and without medical professional involvement.^[9] Some researchers have responded to this lack of evidence to backup mobile medical apps by designing studies to validate the functionality of medical apps.^[13] Furthermore, Happtique, a New York-based developer of mHealth solutions, developed a set of criteria for certifying general medical apps in close cooperation with American Association of Medical Colleges.^[11] Another possible solution to the

problem is having a requirement for health-related apps to provide full-authorship disclosure to clarify medical professional involvement and increase trust and reliability of these apps. Until further oversight or regulation guidelines are released, clinicians are advised to personally assess the validity of medical apps prior to use.

Concerns about smartphone use in medical setting

The use of smartphones in the medical setting raises several ethical and medico-legal concerns. Besides concerns about app oversight and regulation, there is an increased risk of pathogen spread,^[2] possible breach of patient confidentiality,^[18] and increased likelihood of physician distraction.^[30] Although there are some institutional policies in place to address these concerns, the policies must be updated constantly to review precautions and provide continuous reminders for surgeons and trainees. Since use of technology could also detract from personal communication required for surgical care, it is ultimately the responsibility of the neurosurgeon to make decisions based on appropriate medical information and clinical judgment to ensure the safety of patients.

Other general medical apps

There are several apps like Epocrates (drug reference app) and Safe Surgery (Official WHO safe surgery checklist) among many others that may increase productivity and efficiency of surgeons and physicians in general. These apps are not specific to neurosurgery so they were not included in this review.

Study limitations

This study has several limitations due to its reliance on subjective consumer reviews and information provided by the app developer that may be potentially biased for marketing purposes. Additionally, the app stores are very dynamic; apps are continuously being produced/updated, prices are being changed based on popularity and customer reviews are being added. Since most apps did not have enough current reviews due to recent updates, the average rating for apps was collected over all versions of an app, which may underestimate the actual current average rating after an app has been updated. Authorship disclosure was also difficult to identify so medical professional involvement may have been underestimated.

Future directions

Studying the effectiveness of neurosurgical apps in improving productivity/efficiency and providing education to trainees and obtaining informed consent from patients will provide valuable information on whether the benefit of using clinical apps outweighs their risks.

Conflict of interest

All authors of this manuscript disclose no conflicts of interest with publication of the manuscript or

an institution or product that is mentioned in the manuscript and/or is important to the outcome of the study presented or with products that compete with those mentioned in the manuscript.

REFERENCES

- Barton AJ. The regulation of mobile health applications. *BMC Med* 2012;10:46.
- Brady RR, Verran J, Damani NN, Gibb AP. Review of mobile communication devices as potential reservoirs of nosocomial pathogens. *J Hosp Infect* 2009;71:295-300.
- Brewer AC, Endly DC, Henley J, Amir M, Sampson BP, Moreau JF, et al. Mobile applications in dermatology. *JAMA Dermatol* 2013;149:1300-4.
- Carter T, O'Neill S, Johns N, Brady RR. Contemporary vascular smartphone medical applications. *Ann Vasc Surg* 2013;27:804-9.
- Cenydd LA, John NW, Phillips NI, Gray WP. VCath: A tablet-based neurosurgery training tool. *Stud Health Technol Inform* 2013;184:20-3.
- Chang AY, Ghose S, Littman-Quinn R, Anolik RB, Kyer A, Mazhani L, et al. Use of mobile learning by resident physicians in Botswana. *Telemed J E Health* 2012;18:11-3.
- Franko OI, Tirrell TF. Smartphone app use among medical providers in ACGME training programs. *J Med Syst* 2012;36:3135-9.
- Franko OI. Useful apps for orthopedic surgeons. *Am J Orthop (Belle Mead NJ)* 2012;41:526-7.
- Haffey F, Brady RR, Maxwell S. A comparison of the reliability of smartphone apps for opioid conversion. *Drug Saf* 2013;36:111-7.
- Hamilton AD, Brady RR. Medical professional involvement in smartphone 'apps' in dermatology. *Br J Dermatol* 2012;167:220-1.
- Happtique. Available from: <http://info.happtique.com/mobile-health-certification-standards> [Last accessed on 2013 Dec 27].
- Husain I, Wodajo F, Mistra S, Schultz C, Lewis T, Aungst T. iMedicalApps The iMedicalApps Reviews and Commentary by medical professionals. Available from: <http://www.imedicalapps.com/about/> [Last accessed on 2013 Dec 27].
- Jacquot F, Charpentier A, Khelifi S, Gastambide D, Rigal R, Sautet A. Measuring the Cobb angle with the iPhone in kyphoses: A reliability study. *Int Orthop* 2012;36:1655-60.
- Kubben P. NeuroMind 2: Interactive decision support for neurosurgery. *Surg Neurol Int* 2012;3:109.
- Kubben PL. Neurosurgical content for mobile devices. *Surg Neurol Int* 2010;1:46.
- Kubben PL. SLIC 2: Improved decision support for subaxial cervical spine injury. *Surg Neurol Int* 2012;3:30.
- Makanjuola JK, Rao AR, Hale J, Bultitude M, Challacombe B, Dasgupta P. Urology apps: A review of all apps available for urologists. *BJU Int* 2012;110:475-7.
- Mole DJ, Fox C, Napolitano G. Electronic patient data confidentiality practices among surgical trainees: Questionnaire study. *Ann R Coll Surg Engl* 2006;88:550-3.
- Moodley A, Mangino JE, Goff DA. Review of infectious diseases applications for iPhone/iPad and Android: From pocket to patient. *Clin Infect Dis* 2013;57:1145-54.
- O'Neill S, Brady RR. Colorectal smartphone apps: Opportunities and risks. *Colorectal Dis* 2012;14:e530-4.
- Research2Guidance. Global smart phone application market report 2012, update 1st half year 2010. Research2Guidance; 2010.
- Rodrigues MA, Visvanathan A, Murchison JT, Brady RR. Radiology smartphone applications; current provision and cautions. *Insights Imaging* 2013;4:555-62.
- Stevens DJ, Jackson JA, Howes N, Morgan J. Obesity surgery smartphone apps: A review. *Obes Surg* 2014;24:32-6.
- Top Ortho Apps. Available from: <http://toporthoapps.com/about/> [Last accessed on 27 Dec 2013]
- Tahiri Joutei Hassani R, El Sanharawi M, Dupont-Monod S, Baudouin C. Smartphones in ophthalmology. *J Fr Ophtalmol* 2013;36:499-525.
- U.S. Food and Drug Administration. Mobile Medical Applications: Guidance for Industry and Food and Drug Administration Staff. Available from: <http://www.fda.gov/downloads/MedicalDevices/DeviceRegulationandGuidance/GuidanceDocuments/UCM263366.pdf> [Last accessed on 2013 Dec 28].

27. Wee CC, Pratt JS, Fanelli R, Samour PQ, Trainor LS, Paasche-Orlow MK. Best practice updates for informed consent and patient education in weight loss surgery. *Obesity (Silver Spring)* 2009;17:885-8.
28. Wickland E. Epocrates study cites advantages to providers and patients in using drug reference apps. 2013. Available from: <http://www.mhimss.org/news/epocrates-study-cites-advantages-providers-and-patients->

using-drug-reference-apps [Last accessed on 2013 Dec 27].

29. Workman AD, Gupta SC. A plastic surgeon's guide to applying smartphone technology in patient care. *Aesthet Surg J* 2013;33:275-80.
30. Wu R, Rossos P, Quan S, Reeves S, Lo V, Wong B, et al. An evaluation of the use of smartphones to communicate between clinicians: A mixed-methods study. *J Med Internet Res* 2011;13:e59.

Commentary

In the beginning of this millennium, personal digital assistants (PDAs) started to get used increasingly. This also resulted in scientific articles about the added value of their use, including a short humoristic essay about an updated version of the residents' palmomental reflex.^[2] Later, a good review was published by Baumgart *et al.*, which, less than 10 years later, clearly is outdated by the rapid developments in this field.^[1]

Since the introduction of the iPhone in 2007, things have changed dramatically for the good. Modern smartphones are capable of more than we ever imagined, with a usability that is even better than regular personal computers. We are equipped with multitouch multimedia platforms with excellent audiovisual capacities, GPS tracking systems, accelerometers, high-quality cameras with videoconferencing built-in, persistent internet connection at high speed, and app stores with a large variety of applications that can be downloaded immediately. Tablets have been added to the hardware portfolio, and a variety of operating systems are available based on personal preference.

This also led to a large number of medical apps. With that comes the responsibility to classify these apps. The U.S. Food and Drug Administration (FDA) and

other organizations are demanding for quality assurance programs or certifications because some apps are to be considered as medical devices. To decide upon whether an app is actually a medical device or not, several guidelines are available based on the underlying organization.

Besides these top-down regulations, many bottom-up evaluations have been performed. This happens either online by weblogs dedicated to medical apps (e.g., iMedicalApps.com) or by publications in peer-reviewed journals. This article by Zaki and Drazin offers a recent overview of what we need to know about medical apps for neurosurgery.

Neurosurgery in the app era: It really is "all in the wrist"!

Pieter L. Kubben

Department of Neurosurgery, Maastricht University
Medical Center, Maastricht, The Netherlands.
E-mail: pieter@kubben.nl

REFERENCES

1. Baumgart DC. Personal digital assistants in health care: Experienced clinicians in the palm of your hand? *Lancet* 2005;366:1210-22.
2. Crelinsten GL. The intern's palmomental reflex. *N Engl J Med* 2004;350:1059.