THE PROMISE OF VOICE:
CONNECTING DRUG DELIVERY THROUGH VOICE-ACTIVATED TECHNOLOGY

In this article, Chris Franzese, Lead Clinical Analyst, and Marty Coyne, Principal and Founder, both of Matchstick, discuss the vast potential that voice-activated technologies, such as Amazon's Alexa, have in the healthcare market. Running through the challenges posed by data security and human factors, they go on to explain how the rewards voice-activation offers are well worth the effort, spanning the drug delivery experience.

MARKET PENETRATION, USER TRUST & POTENTIAL FOR HEALTHCARE

Since the introduction of Apple's Siri, the first voice-activated assistant installed on a smartphone, voice-activated technology has become increasingly accessible to users. The voice-activation market has expanded to encompass technology from other tech giants like Google (Home), Amazon (Echo) and Microsoft (Cortana). According to a recent projection, by the end of this year 35.6 million Americans will use such technology at least once a month, a 128.9% increase over last year.[1] This interest continues to build – a 2017 report by Parks Associates found that 56% of US households with broadband access find it appealing to use voice assistance to control smart home devices.[2]

Amazon, as the first company to embrace the technology, has dominated the market, having an estimated 70.6% share of consumers using its Alexa-enabled devices.[1] According to data on recent internet trends, Amazon shipped approximately one million Echo devices in the first quarter of 2016 alone, with the total number of devices installed in the US to date quickly approaching 12 million.[3,4]

Amazon has also pioneered the employment of voice-activation beyond consumer use, notably having been behind some of the early applications of this technology in healthcare. Some examples include Kids MD, a program (termed an "Alexa Skill" by Amazon) designed by Boston Children's Hospital to deliver advice about fever management to parents of sick children; WebMD, which employs the well known website to answer basic health-related queries; and, most recently, Sugarpod, an integrated scale and mobile app concept developed by Wellpepper for patients with type 2 diabetes.[5-7]

PATIENT PRIVACY & DATA SECURITY

Thus far most applications of voice-activation have been targeted towards consumers, rather than the healthcare market. This is starting to change however, and as the technology moves into healthcare it also takes its first steps into a far more regulated environment than that of consumer products. For instance, in the US, where voice-activation adoption has occurred most rapidly, the biggest questions surround the privacy and security of protected health information (PHI), as detailed in the Health Insurance Portability and Accountability Act (HIPAA) Privacy Rule and Security Rule.

In short, the Privacy Rule provides legal protections for individually identifiable health information held by HIPAA "covered entities" (healthcare providers, health plans or healthcare clearinghouses) and their "business associates" (those who are authorised to use this information on a covered entity's behalf). This includes giving patients the right to obtain a copy of their PHI, know the identity of those who have received their information and request limits on who may access it.[8]

The Security Rule, on the other hand, specifies a series of administrative, physical

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and technical "safeguards" that covered entities and their business associates must implement to prevent unauthorised or inappropriate access, use or disclosure of electronic PHI. This involves assuring clear policies and procedures are in place, risk management is conducted and data is appropriately encrypted both at rest and during transmission.[8]

Whilst many components of Amazon's ecosystem are currently HIPAA-compliant, Alexa is not. This fact has shaped, and effectively limited, the capabilities of currently marketed healthcare Alexa Skills. Firstly, because HIPAA regulations strictly apply to covered entities, Amazon's voice-activation cannot yet be employed in clinical settings where patient information is collected and used (e.g. via integration with electronic medical records). Secondly, without access to a patient's full clinical picture (e.g. medical history, medications, laboratory values), Alexa cannot act on the information it receives to deliver true medical interventions. Instead, it is currently limited to activities like patient self-monitoring and simple data retrieval. For example, Alexa may be able to tell a diabetic patient what their last blood glucose reading was and how many carbohydrates their lunch contains, but it cannot instruct them on how many units of insulin they should take to accommodate their meal, given other factors like insulin sensitivity, concomitant anti-diabetic drugs or recent exercise.

With the recent shift in drug delivery towards patient self-medication, the limitations on voice-activated technology seem likely to change. A 2016 report to Congress serves as an early indicator, where the US Department of Health and Human Services highlighted significant gaps that exist in current legislation with regard to digital health.[9] Still, there are more than technological and policy barriers that must be overcome to ensure voice-activation is ready to realise its healthcare potential.

UNIQUE HUMAN FACTORS OBSTACLES

If voice-activation is to be used alongside, or in conjunction with, medical devices in a clinical setting, it must receive rigorous scrutiny from a human factors perspective. As with medical devices, voice-activated technology must account for specifics of the intended user and use environment to ensure safe and effective use. Unlike most medical devices, where the user interfaces with the device in a primarily tactile and visual manner, voice-activation is an inherently intangible interaction and singular mode of feedback, therefore presenting distinct usability challenges. Some of these challenges were highlighted in a recent analysis of Amazon Alexa user reviews.[10]

User Specific Human Factors

In traditional medical device human factors studies, user specific requirements typically take into account variables like physical dexterity, cognitive abilities/limitations, literacy/language skills and mental/emotional state, all of which may be influenced by an individual patient's disease or comorbidities. Where voice is concerned, these considerations could manifest as differences in pronunciation (including accent), volume or word choice, all of which are factors that may be specific to, or influenced by, an individual's disease.

In practice, patients may misname, mispronounce or use a number of different terms to describe their drug delivery device ("injector", "pen", "needle", "shot"), treatments ("metformin", "medformin", "met") or laboratory measures ("blood glucose", "BG", "sugars"). Failure to test for these nuances during human factors studies and anticipate these events during actual use could pose significant risk to patients where voice-activated technology is involved, especially if easily mistaken terminology is involved – such as look-alike and sound-alike medications.[11]

To reduce the potential for errors, human factors research must not only allow for synonyms, but also consider the importance of interpreting what is said in the appropriate context, which will require significant clinical knowledge and input during testing. For example, the drug Celebrex, an oral anti-inflammatory agent, should never be confused with Cerebyx, an intravenous anti-epileptic, if a patient is asking for help managing their osteoarthritis. Similarly, Lantus, a long-acting basal insulin typically taken once daily, should never be recommended in lieu of a rapid-acting insulin to a patient asking how many units they should take to cover their mealtime carbohydrates.

Use Environment Specific Human Factors

Use environment specific human factors considerations are complicated by the voice interface as well. Location and distance relative to the voice-activated device must be taken into account. If the device resides in the kitchen for instance, medications must be taken in close proximity for voice-activation to be maximally utilised. The most significant use environment challenge for voice-activation involves managing unauthorised interactions, either inadvertent or intentional, in different settings. As mentioned previously, accidental disclosure of PHI is not of particular concern when it comes to self-medication in home use environments. In this setting, human factors considerations may be more focused on eliminating accidental input of information from unintended sources, such as a television advertisement or casual conversation. On the other hand, the potential for breach of PHI must be taken very seriously if the intended use environment is a busy clinical setting, where several patients are being treated in close proximity (e.g. doctor's offices, hospitals, assisted living facilities or long term care settings).

POTENTIAL TO IMPROVE THE DRUG DELIVERY EXPERIENCE

Although the voice interface creates specific human factors challenges, it also holds tremendous promise to enhance the user experience. More than any other interface, voice facilitates a more natural, human, intuitive and instinctive interaction with technology. Preliminary research has shown that voice-activation is already being used to both improve the healthcare experience

Scenario	Goal	Patient/Caregiver Interaction	Example Voice-Activated Technology Response
Onboarding and training	Increase confidence and "walk through" use steps	"Alexa, what do I do next?"	"Okay, now that you have the injector pressed against your skin, it's time to inject. Whenever you're ready, press the green button on top with your thumb – you might feel a quick pinch when the needle goes in…Good job, the medication is being injected now. Keep holding, and I'll let you know when it's done."
Medication reminders	Manage medications inclusive of entire therapy regimen and routine	"Alexa, I just took my metoprolol. When is my next dose?"	"Great, I'll log that. Your next metoprolol dose is at 7 pm – I'll remind you when you get home from your staff meeting today. Also, don't forget today's a Humira day too. What time do you want to do that?"
Symptom management	Capture and deliver ancillary information related to diseases and treatments	"Alexa, my peak flow is 60% after being outside all day. Can you add ragweed as a trigger?"	"Sure, I added it with today's date and your peak flow reading. Do you need me to read through your asthma action plan?"
Caregiver engagement	Monitor patients and their self-care	"Alexa, did Dad take his Sinemet today?"	"He took Sinemet at 8am but is one hour late for his second dose. Would you like me to remind him? I'll get back to you when he takes it."
Patient support	Incorporate conversational and motivational elements	"Alexa, why am I even taking this lisinopril? It does nothing for me."	"You may not feel your lisinopril working, but it's still important to take it. It keeps your heart and kidneys healthy."

Table 1: Hypothetical voice-activation and patient/caregiver interactions.

and build trust with patients and that, moreover, voice offers unprecedented device accessibility to those with physical or neurological disabilities.[10] These benefits are of particular note when it comes to drug delivery, where patients are faced with increasingly complex medication regimens and unfamiliar delivery devices. Table 1 summarises examples of interactions that could be possible as technical and voice recognition capabilities improve.

Onboarding and Training

Therapy initiation often tends to provoke anxiety due to the unfamiliarity and uncertainty associated with starting a new therapy, especially if that medication requires a delivery device (e.g. an auto-injector, on-body injector, nebuliser or inhaler). Even with oral medications, the prescribed regimens can be complex and involve different medications taken at different times.

Voice-activated technologies show great potential to improve the process of initiation. Rather than the patient relying on written instructions for use, voice-activation could be employed to walk patients through the injection process from start to finish. With the advent of connected drug delivery devices, voice-activation could also be programmed to acknowledge specific steps, such as needle guard

removal, skin contact, injection initiation and end-of-dose. Several studies have demonstrated the benefit of such multisensory interaction (i.e. the combination of visual, audio and tactile stimuli) on improving learning capacity.[12,13] Other studies have correlated more intensive device education and training with reduced rates of use errors.[14,15]

Medication Reminders

Non-adherence to medication is a well known and perennial problem across multiple disease states and medication regimens. A myriad of technologies, including hundreds of mobile applications, currently exist to help patients remember to take their medications consistently. Although forgetfulness is only one of many contributors to non-adherence, voice-activation has clear potential to help facilitate medication tracking and reminders in a way that is more patient-friendly, encompasses all of that patient's medications (i.e. polypharmacy) and is more compatible with their daily routine.

Symptom Management

Patients with some chronic diseases (e.g. psoriasis, asthma, COPD, migraine, heart failure, cystic fibrosis, lupus) often experience symptomatic periods or disease exacerbations that may be associated

with specific triggers or have defined management strategies. These patients may find it useful to capture trigger information and be reminded of how they've alleviated symptoms in the past. Those who experience side effects due to one or more of their medications may benefit from a similar practice. Voice-activated technology has the potential to deliver this information whenever patients need it.

Caregiver Engagement

Caregivers play a significant role in helping patients manage their disease, particularly if the condition is debilitating or complex. Unfortunately, caregivers often carry the full burden of a patient's condition, which may negatively impact their own lives. Voice-activation could play an important role as an intermediary between caregivers and their patients, potentially lessening the load. An ongoing study is currently exploring whether voice-activation could reduce the demands on caregivers for patient with learning disabilities.[16]

Patient Support

Perhaps the most impactful aspect of the voice interface is its unique ability to provide a feeling of personal interaction with users. In the aforementioned analysis of Amazon Echo reviews, a large percentage of users

consistently saw "her" (Alexa) as a friend or family member. This sense of trust and companionship makes voice-activation a promising medium for delivering motivation and support to patients in a way regular smartphone applications cannot.

THE FUTURE OF VOICE

The regulatory space around voice-activated technology is still evolving, and will be a significant inhibitor or accelerator of voice technologies for more sophisticated interventions. It is currently unclear whether voice-activation will require a similar degree of FDA regulation to that of mobile medical apps (MMAs) where delivering medical interventions is concerned. Regardless of emerging regulatory frameworks, early research has revealed that "do it yourself" voice approaches are already being implemented by patients, and these solutions highlight clear, unmet human factors needs. However, this research also provides indications that, for at least some patients and caregivers, voice-activation provides an added layer of companionship, conversation and assistance that, when executed well, is perceived as authentic and authoritative. Manufacturers cannot ignore the opportunity to add additional tools that complement existing investments and drive patient engagement, and must begin to consider voice-activation approaches, trusting that regulations will "catch up" to the promise these technologies offer.

For voice-activation in the drug delivery space, it is clear that maximum value will be provided when the entire system is context-sensitive to individual patients, diseases and therapies. Clinicians, such as those with experience in patient counselling, medication therapy management and clinical decision support, will play an increasing role alongside traditional human factors practitioners in navigating the permutations that lead to potential use errors.

ABOUT THE COMPANY

Matchstick is speciality consultancy focused on pre-concept and concept stage development of combination products including devices, patient support and engagement programmes, training and lifecycle strategies. Matchstick helps firms understand unmet patient and caregiver needs, invent useful and relevant product and service solutions to those needs and help clients deliver compelling business cases to drive programmes forward within their organisations.

REFERENCES

1. "Alexa, Say What?! Voice-Enabled Speaker Usage to Grow Nearly 130% This Year". eMarketer, May 2017.

2. "Voice Assistants and Technologies: Ecosystem and Market Leaders". Report, Parks Associates, March 2017.

3. Meeker M, "Internet Trends 2016". Report, Kleiner Perkins Caufield & Byers, June 2016.

4. Meeker M, "Internet Trends 2017". Report, Kleiner Perkins Caufield & Byers, May 2017.

5. Comstock J, "Boston Children's Hospital Launches Amazon Alexa App KidsMD". Healthcare IT News, April 2016.

6. Mack H, "WebMD integrates with Amazon Alexa to offer health information through voice assistant". MobiHealthNews, March 2017.

7. Weiler A, "Introducing Sugarpod by Wellpepper, a comprehensive diabetes care plan". Wellpepper Blog, July 2017.

8. "HIPAA Administrative Simplification Regulation Text". US Department of Health and Human Services Office for Civil Rights, March 2013.

9. "Examining Oversight of the Privacy & Security of Health Data Collected by Entities Not Regulated by HIPAA". US Department of Health and Human Services, July 2016.

10. Coyne M, Thomas C, Collimore A, Franzese C, Hwang C, "Early user centered insights on voice integrated technologies through retrospective analysis". iproc, 2017, Vol 3(1), e49.

11. "ISMP's List of Confused Drug Names". Institute for Safe Medication Practices, February 2015.

12. Shams L, Seitz AR, "Benefits of multisensory learning". Trends Cogn Sci, 2008, Vol 12(11), pp 411-417.

13. Shams L, Wozny DR, Kim R, Seitz A, "Influences of multisensory experience on subsequent unisensory processing". Front Psychol, 2011, Vol 2, article 264.

14. Sicherer SH, Forman JA, Noone SA, "Use assessment of self-administered epinephrine among food-allergic children and pediatricians". Pediatrics, 2000, Vol 105(2), pp 359-362.

15. Arkwright PD, Farragher AJ, "Factors determining the ability of parents to effectively administer intramuscular adrenaline to food allergic children: Injectable adrenaline for food allergy". Pediatr Allergy Immunol, 2006, Vol 17(3), pp 227-229.

16. Gidley S, "Smart speaker technology trial to aid supported living". BBC News, November 2017.

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Marty Coyne is Principal and Founder of Matchstick. He has 20 years of experience with implantable and disposable medical devices, particularly drug delivery devices used in acute care, ambulatory and home settings. A thought leader on sharps injury protection, safe injection practices and healthcare worker and patient safety, he has innovated extensively in these areas individually and for clients, with 11 patents issued and over 40 patents pending. Mr Coyne has a BE in Mechanical Engineering from Stevens Institute of Technology (Hoboken, NJ, US) and an MBA from Columbia University (New York, NY, US).