Chapter 11
Crowdsourcing Cooperation for Better Clinical Outcomes

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Introduction

Article 25 of the Universal Declaration of Human Rights [9] establishes that all of us are entitled to medical care. This is easier said than done, especially when combined with the dominant justice and equity theme of the declaration. We may disagree if equity of medical care is realistic; however, most of us agree that it is a worthy goal. In this paper, I will present a new platform that facilitates cooperation in the sharing of medical knowledge that can address health equity challenges.

To illustrate the complexity of providing equity in medical care, imagine twins born in a poor community. A well-to-do couple in Boston adopts one child while the other child remains in the orphanage. Let us assume due to their genetic makeup, both have diabetes. Equity of care means both twins should have the same life expectancy. Dr. Paul Farmer [8] eloquently discussed equity and its importance for our global health and prosperity.

Urban communities are very diverse in terms of ethnicity, age, and income. They are made up of people from different backgrounds. Statistically, to improve care of such communities, we need to provide care that reflects the ethnic diversity of a community; otherwise, we will unintentionally neglect providing equitable care to people who paid for it and expect it. To do this properly, our medical research and practices should cover all races and genetic backgrounds and not only that of the majority of well-developed communities.

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To achieve better care, we need to share information, knowledge, and practices. We also need to work together to solve local problems with global resources. That is, to solve an Ebola outbreak in West Africa, we need the knowledge of medical doctors in other parts of the world who have valuable expertise in that area who can work to complement local resources.

Connectivity and the Internet made the world smaller. Most of the world is connected (e.g., According to GSMA [3], as of 2015, half of the world has a mobile connection growing to 60 % in 2020). More importantly, 45 % of the developing world population is connected). People now exchange ideas, information, and work on projects regardless if they are in the same physical location or not. This leads to a new important tool: crowdsourcing.

According to the Merriam-Webster dictionary, crowdsourcing is "the practice of obtaining needed services, ideas, or content by soliciting contributions from a large group of people and especially from the online community rather than from traditional employees or suppliers." In a sense, it is brainstorming with experts with different backgrounds and experiences to solve a problem.

Crowdsourcing can be more powerful than traditional research, opinion polling, and one-on-one consultation. When you read an article, you are limited by your interpretation of the concept. Reading other interpretations and asking people for their opinion broadens the understanding and opens more solution avenues. Imagine medical professionals from different backgrounds discussing a certain outbreak, the collective knowledge of this group will be much larger than that of one consultant or specialist.

Crowdsourcing and open collaboration is an important tool to bridge the geographic knowledge gap. Specialists and experts from any part of the world will be able to provide specific opinions and help people that do not have access to such knowledge. Moreover, the specialists and experts will be exposed to more information by working on more problems and more scenarios.

Connectivity + crowdsourcing are fundamental and important tools to provide equity of care and improve the overall care of everyone. This chapter will discuss using crowdsourcing for healthcare.

Medical Information and Knowledge Is Special

Medical information deals with our physical and mental quality of life. In many cases, medical information could be the difference between life-and-death situations. For this reason, we should deal with medical knowledge and information differently. Discussing the treatment of a cancer patient is different that discussing how to restart a stalled car. The discussion forums are not for everyone. Moreover, few opinions matter even among doctors. For example, the opinion of a cardiologist about how to treat prostate cancer is not as relevant when compared to that of an oncologist.

Medical knowledge is built upon clinical cases. Access to the knowledge means applying it to scenarios that include people, symptoms, and environment. Moreover, the scenario is not always static. What this means is sharing medical knowledge is providing accessibility to a complex set of tools and actions that depend on changing scenarios.

The other important fact about medical knowledge is that its application may differ from one patient to another. The diagnosis may depend on social practices that the patient may not be comfortable sharing in public, or on genetic makeup that the patient would rather keep secret. At least 70 % of health outcomes are related to social, environmental, and behavioral issues that are managed outside of the clinic. This personal nature of the medical discussion demands significant attention to privacy and security.

Sources of Medical Knowledge

Practicing medicine depends on knowledge acquired by evidence (evidence-based medicine) and experience [1]. Both are very important. Evidence-based medicine provides information and knowledge based on carefully conducted experiments by researchers and experts. It is typically adopted and confirmed by prestigious medical board organizations. Medical experience is important because medicine is personal. Thus, the knowledge acquired by a clinician is important because they know firsthand what works best under certain circumstances.

Any medical information or collaboration tool must draw from these important sources. Moreover to succeed, such tools must:

- Be for everyone involved in the care of a patient and reviewed by medical experts. This includes direct feedback from the patient as her/his own advocate.
- Guarantee security and privacy.
- Embrace the dynamic nature of clinical encounters. Clinical discussions are not a typical question/answer sessions. They involve monitoring, follow-up, and multi-disciplinary opinions as well as coordination with a care management team for high-risk patients.

Collaboration and crowdsourcing are very important tools to communicate medical knowledge and improve it. If we are successful in building a viral application for medical professionals like Facebook, we can communicate state-of-the-art medical knowledge efficiently. Moreover, doctors can collaborate together to advance knowledge and exchange information, thus improving the overall knowledge of everyone.

Collaboration and Crowdsourcing in Healthcare

The main objectives of crowdsourcing in healthcare are:

- To provide access to specialists, i.e., medical professionals with special expertise and knowledge.
- To get fast conclusions on clinical cases based on expert-crowd-collective knowledge.

Applying crowdsourcing solutions to healthcare is not straightforward. There are special constraints in healthcare that need to be addressed in any solution, in particular:

- Privacy of patients and their information.
- Validity of the results.
- Legal and moral responsibility of the advices and contributors.

In the last couple of years, new types of healthcare applications have emerged that try to utilize medical doctors to provide expertise. The main categories of those applications are:

- Public expert question and answer applications: User post questions in a public forum and forum participants comment, advice, and suggest solutions. Typically in such applications, there are two kinds of participants: general audience and verified experts. Only experts with verified credentials can contribute. Everyone else are just readers of the interaction. Examples of such applications include Fig. 11.1 and CrowdMed.
- Public patient–doctor question and answer forums. Such applications provide a forum for the general public to ask doctors. Doctors can interact and provide answers. There are a large number of such applications including HealthTap, Sermo, and First Derm. The main problem of such applications is that many clinical cases require more interaction with the doctor than just posing a question. Moreover, patients may come to the wrong conclusion.
- Data Forums and centers. These are important forums where researchers post depersonalized data that other researchers can analyze and use in their research. Typically, results are published in peer-reviewed research conferences and journals. The interactions are delayed and not immediate.

Most of existing crowdsourcing healthcare applications focus on depersonalized clinical cases. Patients typically are presented with "Terms of Service" that are drafted to protect the application provider, the forum and their advisors. The "Terms of service" typically make it clear that the patient should consult her/his physician, who has the final say for that patient's care. Although these applications advance collaboration between doctors, their impact will be limited, mainly for the following reasons:

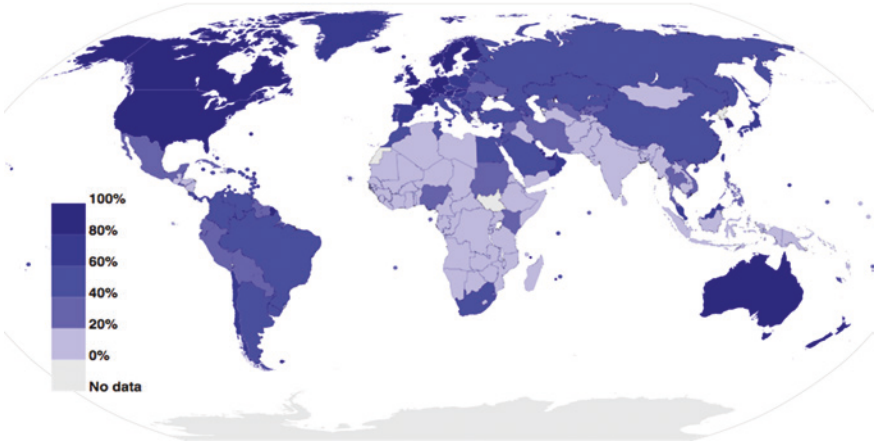

Fig. 11.1 Internet users as percentage of country population (from Odgen [7]; Jeff Ogden's own work, based on figures from the Wikipedia list of countries by number of Internet users article in the English Wikipedia, which is in turn based on figures from the International Telecommunications Union (ITU) for 2010 (updated to use figures for 2012 on 28 June 2013). http://en.wikipedia.org/wiki/Global_Internet_usage#mediaviewer/File:InternetPenetrationWorldMap.svg)

- Question and answer forums do not easily provide a vehicle for clinical case update, questioning, and medical test and care follow-up. The discussions are done in a spontanenous manner and it is the responsibility of the expert provider to connect the threads.
- Public discussions may have legal risks, resulting in many experts refraining from participating.
- The business models of such applications are under scrutiny. To elaborate, free applications claim that they will sustain their business by either advertisement or by sponsoring questions. The advertisers and sponsors are typically pharmaceutical companies, thus some may argue that this creates a conflict of interest. This is more concerning when the application providers pay for expert opinions, which is typically done to increase user base and market the application.

A new paradigm of crowdsourcing application is emerging. Such applications focus on building "virtual clinics," where medical professionals form a virtual clinic to discuss and solve medical cases. The main differentiator is that the discussion is private and not open to the public. This will make it easier to satisfy HIPAA and other privacy requirements allowing for more access to information and follow-up.

It is important to differentiate between this new category of applications and electronic medical records (EMR). An EMR system focuses on documenting a case. It does not focus on exchanging opinions and exploring diagnoses. The private forum provides this functionality. Examples of such applications include Tabeeb.

Crowdsourcing and Collaboration Are Access Tools for Knowledge and Expertise

Medical doctors are the center, brain, and heart of any healthcare system. Doctors, nurses, practitioners, medical assistants, and insurance companies must be aligned and in full communication to provide the best care for the patient. Access to medical doctors with special skills is key to providing the highest-quality care. We need cardiologists to diagnose and treat heart patients. We need oncologists to diagnose, treat, and care for cancer patients. Nurses and assistants administer the treatment and the specialist's knowledge is essential to providing quality care. Moreover, the role of nurses has evolved so much that they are becoming the responsible for primary care and in many cases chronic disease care.

Technology is enabling a virtual approach to healthcare, democratizing medical knowledge so that access to knowledge can be distributed and effectively used by more skilled healthcare professionals beyond doctors physically located with the patient.

Insurance companies can benefit from virtual healthcare by utilizing the best medical advice via crowdsourcing experts in their sphere of influence. Hospitals and clinics can financially benefit by providing experts advice to customers outside their geographic areas.

State-of-the-art medical information comes from different sources: bioscience research, clinical research, clinical practices and experiments, colleagues, healthcare data, and patients. It is important for us to provide tools that are integrated into clinical workflows for physicians to learn, interact, and share information while knowing that the source is trustworthy and the communication is secure.

It is also important to provide doctors with a platform or forum where they can ask questions and give opinions without the fear that this will impact their careers, and create legal risks. They need to be experts and students at the same time. Social media services, such as Facebook and Twitter, drafted Terms of Use policies that protect the company, not the users. For medical crowdsourcing, we need to encourage experts to participate by promoting their knowledge and legally protecting them from any backlash. We need new terms of service language for doctors and patients.

To summarize:

- Medical doctors are the heart of healthcare.
- Medical information can come from many sources. However, the credibility of the source is critical.
- Clinical decisions involve a significant number of factors.
- Healthcare systems have different constraints than other fields.

I will now provide a discussion for each of these four points.

Modeling Crowdsourcing and Collaboration Based on Typical Medical Interactions

Medical doctors' interaction with each other consists of:

- Person-to-person consultation. This could be a specialist asking the primary care physician for more information, a primary care physician confirming a diagnosis with a specialist or a doctor asking for advice. It is currently done via phone calls, emails, or private chats. It is limited to people who you know.
- Group discussions. This is when doctors and other medical professionals discuss a case together. They use collective knowledge to diagnose and create a care plan. It is currently done in-person.
- Medical community discussions. This is where people share experiences and research. It is currently done via journals and medical conferences.

To develop a comprehensive environment that can take medical professional interactions to the next level, we need a platform that includes:

- Expert-crowdsourcing tools, and
- Comprehensive media communications.

Merriam-Webster dictionary [6] defines crowdsourcing as "*the practice of obtaining needed services, ideas, or content by soliciting contributions from a large group of people and especially from the online community rather than from traditional employees or suppliers*." According to Merriam-Webster dictionary, the first use of the term was in 2006. When we add "expert," we restrict the online community to a group who has verifiable knowledge of the topic at hand. This is an important distinction because it is important that medical information and opinion shared be verifiable and come from a person of knowledge. The information shared will impact quality of life and in certain cases, it is a life-and-death decision.

In an expert-crowdsourcing framework, doctors can exchange ideas and solve clinical cases together. In Tabeeb, a doctor posts a clinical case. The differences between a clinical case in Tabeeb and a social media post are:

- Clinical case information can be categorized in a clinical helpful way for doctors, e.g., history of the patient, symptoms, medication, tests including imaging, and diagnosis hypotheses. A social media post is a picture, video, or text. It is not comprehensive.
- Clinical cases are living entities. That is, the doctor who authored the case can always provide updates for the clinical case with progress or more information. The progress of a clinical case is an important differentiator from just a regular social media post. It provides doctors with a tool to experiment, update, and communicate in a way that resembles what they do on a daily basis.

- Media commenting and communications tools. It is important for doctors to interact together using pictures and videos. Sharing medical images is not enough. Doctors need to comment on pictures, draw on them and express their point of view visually. If we take this to next level, it means interaction between doctors by mimicking what they do with online tools, e.g., whiteboarding on images and annotation of videos and pictures with their voice.

Crowdsourcing enables interesting, informative, and meaningful discussions. If we combine the discussion with expert reviews, we can provide doctors with medical practice recommendations. For example, if three doctors are discussing a cardiac clinical case, the outcome of their discussion can be compared and combined with other ongoing clinical discussions via recommendation and filtering engines. The combination can be edited and reviewed by a panel of experts and promoted to become a practice recommendation. In this new era of expert crowdsourcing, this will expedite how medical practice recommendations are created and communicated.

Expert crowdsourcing can also benefit from online diagnostic tools. Borrowing from the banking industry, where models of different investment and spending habits are created, clinical discussions can also benefit from programmable views of clinical cases.

Appropriate Use Criteria (AUC) are very important for medical practice. AUC specify recommendations and procedures to perform based on evidence and expert opinion [1, 10]. AUC have been computerized. The next important leap for AUC is to utilize natural language processing (NLP) techniques and extract information from a clinical case and provide recommendation to the doctors involved in the discussion. This is the next step for Tabeeb, where it will provide such tools.

State-of-the-Art Tools to Provide Equity Access to Knowledge

Practicing medicine means staying current with a vast amount of biological, medical, sociological, and behavioral knowledge to keep patients healthy. Physician training, despite being quite rigorous, has omitted much of the knowledge required to practice good preventive medicine that is required under new value-based care payment mechanisms. The medical curriculum has not emphasized preventive sciences such as nutrition, public health, and even a great deal of depth in genetics that will be necessary for precision medicine. This means that many physicians will need to learn new skills and also work with new stakeholders. There is also the contextual knowledge that a physician has of a single patient that needs to be taken into consideration with the community, region or group-based knowledge. It is the questions they ask, the data they focus on, the irregularities they observe, the decision process they follow, and the calculated steps they take to analyze, hypothesize, test, diagnose, and recommend a treatment. Such knowledge will distinguish

a good doctor from an average one. Accessing good doctors means better care. However, the best doctor in every field cannot treat each one of us. We need a practical solution.

Corporations and factories when faced with a similar problem solve it by automating processes. If they cannot automate all the actions, they will do their best to automate most of it and scale with providing assistants to the experts. As much as we would love to duplicate this in medicine, we cannot. We can, however, provide tools and platforms for physicians to help them scale and share their skills and knowledge to everyone.

Communications and the Internet

In the twenty-first century, we have acquired more knowledge and tools than in any other time in our human history. For example, in 2012 [4, 5], 39 % of the world population had Internet access (31 % in the developing world and 77 % in the developed world). These grew from 30 % global, 21 % developing world, and 67 % developed world percentage of Internet users in 2010. This means more access to information, knowledge, and more means to communicate with each other. Figure 11.1 shows the Internet users percentage of each country's population.

Affordable personal smart devices

Another important factor is access to mobile devices and in particular, smartphones. Since the introduction of Android devices in 2008, quite a bit has been done to make smartphones affordable to many people worldwide. It is safe to assume that a medical doctor in most countries can afford an Android device (Fig. 11.2).

Free services to read and learn

Anticipating this trend, Yves Maitre d'Amato, Executive Vice President of Connected Objects and Partnerships at Orange, a global mobile operator, challenged device makers and his company to provide access to Wikipedia to African countries. Such initiatives provide access to knowledge and up-to-date information that could not have been done before. Moreover, it is cheaper than building libraries in towns and continuous spending to keep the books and journals up to date.

Wikipedia is a great human achievement. It is the first mass-used crowdsourcing free service. What is remarkable about Wikipedia is that it is built to be a free of charge service. This means anyone, regardless of income, can access this database of knowledge.[1] It is amazing to see the effort many topic-experts have made, to publish and review information using simple straightforward rules. The debate about the accuracy of each point is documented and is accessible to all of us. Peer reviews, peer pressure, collective reading and editing, and individual donations

[1]We do acknowledge that you need access to Internet, which is not free. However, as we have argued earlier, access to Internet is spreading fast. At some point, most of us will have access to Internet and access to this amazing library.

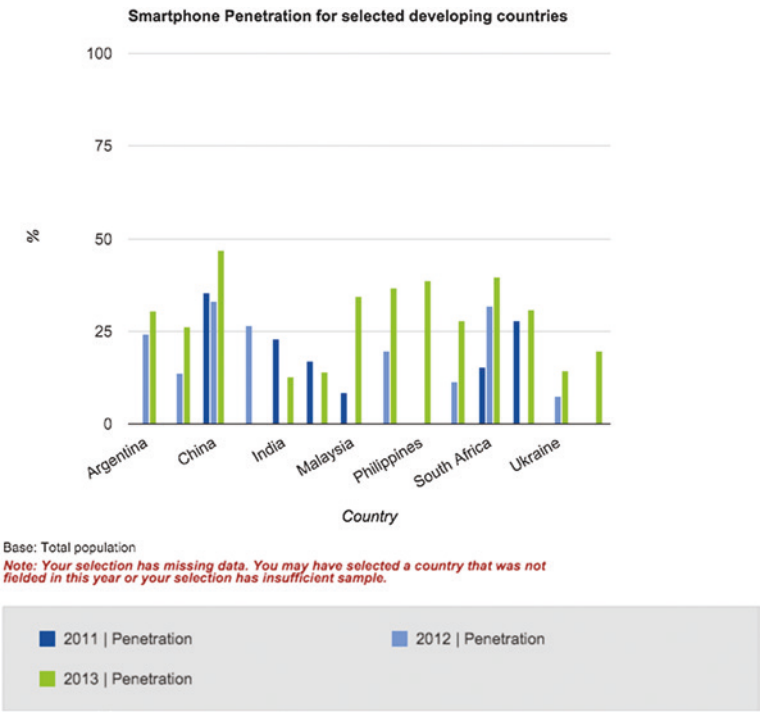

Fig. 11.2 Smartphone penetration as percentage of the population for number of developing countries [2]

made Wikipedia a great, high quality, affordable, and accessible alternative to classic textbooks and encyclopedia.

Wikipedia is a free service funded by all of us and independent of business that may influence information. This is critical for services that provide scientific facts and knowledge. It would be weird to say that the definition of diabetes is brought to you by a candy company. This will impact the credibility of the information.

Such tools are wonderful; however, they are not suitable for healthcare as is. Anyone can change part of a Wikipedia page. This will not be corrected until another person spots it. This is a problem when adopting the Wikipedia approach to healthcare. We need another step in the process: expert certification.

There are important healthcare information services that are accessible to medical professionals. They are peer-reviewed and verified. An example of such a service is UpToDate, a Wolters Kluwer service. The main issue with such a service is that it is expensive especially for medical professionals operating in low-income communities. To their credit, UpToDate does provide discounted rates for people who need it.

We do believe there is a need for a new healthcare Wikipedia that is comprehensive, peer-reviewed, free, and accessible to everyone. New paradigms where doctors can publish their research, get immediate reviews, and communicate results in Internet speed. Crowdsourcing tools can provide such a vehicle.

Successful Medical Professional Products[2]

Table 11.1 shows four different medical professionals platforms and services designed to help doctors. The differences between the four services are in the focus and in the revenue model. Doximity (doximity.com) is a service that verifies credentials of its users. Doximity also provides its users with tools to improve their career prospects and knowledge. Some may argue that Doximity is equivalent to LinkedIn. However, this is not a good comparison. With Doximity, you know that the person you are talking to is a doctor. You know where they graduated from, where they are practicing, and the status of their licenses. The Doximity team worked hard to ensure that their data is as accurate as possible. This is not the case for LinkedIn. This is a substantial difference. We cannot trust the medical opinion of someone whose identity cannot be verified. However, we can rely on the opinion of a surgeon whose identity is verified by Doximity.

Sermo (sermo.com) is one of the pioneers in medical discussion platforms. Their focus is on question and answer sessions. Their application makes it easy to snap a picture and ask a question. It is not designed for involved clinical care. However, it serves a good purpose: quick questions and answers from a specialist. It is very close in concept to Quora or Twitter: Ask a brief question and get an answer as soon as the Sermo team and community responds.

QuantiaMD provides a more sophisticated approach to medical information sharing. They provide doctors with tools to produce high-quality topic-specific or question-specific presentation. It is the equivalent of expert YouTube for medical professionals or Khan Academy. QuantiaMD team reviews and suggests topics. Doctors create presentations and videos for professional education. The outcome is equivalent to building high-quality medical textbooks. QuantiaMD is the publisher and medical professionals are the authors of high-quality media chapters organized by the QuantiaMD team. This platform is excellent for continuous medical education as well as teaching medical students.

Tabeeb's focus is on providing a platform for medical professionals to have live discussions about real-life clinical cases. It builds on crowdsourcing techniques and adapts them to the medical field. Doctors can work with their colleagues on challenging cases, share discoveries, and recommend clinical practices all within a HIPAA-compliant environment. Tabeeb includes easy-to-use imaging and video commenting tools, enabling a very interactive exchange. Tabeeb pays particular

[2]Please note that the author of the chapter is the founder of Tabeeb.

Table 11.1 Summary of four online medical professional only discussion services

Item	Tabeeb	Doximity	QuantiaMD	Sermo
Focus	Clinical case discussions and practice guidelines	Medical professional career growth tools and management	Continuous medical education	Doctor networking
Strength	Clinical discussions. Clinical and media tools	Verifying the identity and expertise of members	High-quality presentations	Question and answer paradigm
Revenue	Subscriptions	Professional placement companies pay to recruit doctors	Sponsored presentations	Revenue from non-medical professionals asking questions

attention to doctors working in impoverished and challenging environments. Specialists can work with them to diagnose cases, provide suggestions for treatment, and follow up with them on the progress of the patient.

Tabeeb's objective is for highly skilled specialists to share their experience with colleagues globally. They can work with them to diagnose cases, provide suggestions for treatment, and follow up with them on the progress of the patient. One way of looking at Tabeeb is that it is the evolution of telemedicine into the twenty-first century communications, i.e., social networking and media collaboration tools. Physicians can post cases, solicit opinions, discuss with experts and colleagues, share progress, and provide feedback. It is working together as a community using state-of-the-art tools.

Where Are We Headed?

The future is bright for medical professionals. They will have tools and platforms that their teachers did not have. Their influence and positive impact will be larger than all their predecessors'. We will all benefit from the new healthcare revolution. To achieve our goals of equity and high-quality care, sharing medical knowledge is critical. For that to be successful, we need the private sector to continue innovating. We also need to mature and expand the current successful platforms. In particular:

- Global Medical Professional Verification System. Doximity has been a great success. We need to see this growth to include medical professionals all over the world. The more successful Doximity is, the more the confidence we will have in the medical opinions shared in all medical platforms. Sermo has a database that includes professionals outside the USA. If Sermo's database reaches the same quality as that of Doximity and if it becomes more open, Sermo will help our cause of access to high-quality medical knowledge.

- Virtual Clinical Discussions. High-quality care cannot be achieved if the experts do not engage with their colleagues. Equity in care cannot be achieved if the person administering the medical care cannot access state-of-the-art practices and knowledge. Platforms like Tabeeb are important to providing best care to anyone anywhere. Moreover, Tabeeb can disseminate new standards for care as they emerge. Currently, it takes a long time for new standards to be communicated to medical professionals, thus impacting quality of care.
- Improved and accessible medical books are fundamental to train for the best medical professionals. QuantiaMD efforts are of great value. Medical schools will benefit from accessing this database. Please note that there are services as in UpToDate, which provides access to journals and traditional publications.

It takes much less effort to achieve our goal of quality equitable care, if we can authenticate every medical professional and provide them with an access to state of the medical knowledge and experience. It is important that such services be affordable to medical professionals in order for them to access the information and use it in their practices. We believe innovative Internet-based business models will enable such services and empower medical professionals. As mentioned above, it is also critical to draft new "Terms of Use and Service" agreements to cover doctors when they participate in such activities.

A media communication and exchange tool, such as Tabeeb, is critical in extending the reach of doctors and experts outside their local communities.

Summary

Doctors and their medical team are a critical factor to providing high-quality care and as such, need the best tools at their disposal to effectively care for their patients. Extending a doctor's reach is essential in providing equitable care.

Verified medical expert identity system + Expert crowdsourcing and communication platform + medical Wikipedia, as defined by the combination of Tabeeb + Doximity + QuantiaMD + UpToDate, will define our next generation of healthcare.

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