CREATING A SINGULARITY BETWEEN MEDICAL KNOWLEDGE AND
HEALTHCARE DELIVERY

Knowledge-Quest Inc.
January, 2016

Executive Summary

1. A singularity has been achieved between medical knowledge, clinical practice and the patient/family.
2. The ramifications of this technology affects all aspects of healthcare delivery:
    a. Knowledge creation and its publication.
    b. Medical education at all levels.
    c. Personal decision support for both the professional and consumer.
    d. Integrated personal exposure to this singularity at the office, hospital and home.
    e. Intelligent advisors and consultants (avatars) to guide, protect and support quality healthcare around the globe.
    f. Language independence with voice interfaces.
    g. Patient specific continuing medical education for all participants.
    h. Extremely low costs and high availability using modern technology.
    i. The potential to minimize the on-the-job training needed for EMR (electronic medical record) adoption and continued operation.
    j. This advanced technology has been successfully deployed in websites and a new medical record design that supports all aspects of this medical singularity.
    k. The singularity engine that drives this intelligent interface is a specially designed relational database that can be used by professionals as well as consumers.
    l. The continuing support and authoring of this new relational medical content has been developed so that hundreds of medical specialists can participate simultaneously with this highly structured medical database. With our systems, only hours exist between the release of

new medical knowledge and clinical application of this new
knowledge around the globe.

m. Our exclusive relational medical database covers every known cause
of human disease or illness and all medical subspecialties.

If any of these objectives are of interest, then you should find the content of this
presentation helpful.

Introduction and Background

"SINGULARITY" has a range of definitions that start with "strange or odd" and extend
to "oneness or singular". For the sake of this discussion and the subject matter under
consideration, the author is going to blend these traditional definitions with the new and
more modern translation that includes the merging of artificially intelligent machines that
approach and perhaps exceed human capability.

In a very obvious sense, this singularity has already been accomplished with cell phones,
GPS locators and most of our modern medical equipment. The cell phone is a very
intelligent machine that allows us to talk and communicate without knowing anything
about the technology or how it operates. It does what humans can't do and it does it better
than any human could ever expect to accomplish. The same can be said for GPS driving
aids that know all the roads and their positions in space. It can certainly do a better job of
navigation than any human and the user doesn't need to know much about the
technology. Both these devices are in a sense past the point of singularity.

In the medical arena there are imaging devices that can do far more than any human by
seeing inside the body in three dimensions. The MRI (Magnetic Resonance Imaging)
machines see more and display information beyond any human's capability. There are
other devices that use sound and radioactive tracers that also see what no human can see.
These devices do not "think" yet and are currently classed as machines.

The piece that is missing in most of these devices is the "intelligent" connection to
interact with humans and problem solve. The medical reasoning and logic frontier is
about to be breached with "intelligent" medical advisors and consultants (avatars). The
access to these technologies could come in several forms and be available to both the
professional as well as the consumer.

For a purist, singularity means that a human will not be able to determine if the device is
a computer or another human. This is called the Turing Test and has been the traditional
benchmark for measuring whether any technology or device has reached "singularity".

This was clearly evident in the movie "2001: A Space Odyssey" where Hal was in charge of human life and ran all the equipment aboard the space ship. Hal could talk and reason and had a limitless memory. At the time of this movie, all this technology was science fiction and was fascinating to contemplate, but had no practical application. What was envisioned as possible is now a reality. We can now build Dr. Hal and much more. The technology has progressed to a cost/application point so that every human on this planet could now participate in this high adventure.

This presentation will describe the tools and technology that has been developed to make this singularity possible and will challenge those who have the financial and technical resources to push this vision forward and make it commercially available.

I. MEDICAL KNOWLEDGE

Medical knowledge has expanded exponentially over the years. It started by word-of-mouth; from one teacher to one student. With the invention of printing, that knowledge could be passed to many students and survive the author or expert. The purification of knowledge has also improved over the years so that one man's opinion is no longer acceptable. We now have textbooks that require hundreds of specialists all working to create a consensus document that best describes the state-of-the-art. These are called medical "Gold-Standards" because they form the basis of our current educational system and all of our certification programs. Today's students are expected to know and memorize what is in these books and be ready to apply this knowledge to a clinical case.

With our modern research tools and the explosion in genetics and cellular biochemistry, we now have a mountain of new data that must be digested and retained by these students. This is a monumental undertaking and requires a four-year medical school program to complete. We then ask these students to become further trained with another three to four year residency in a field of their choice. So far we have seven to eight years of education and still not a fully proficient medical practitioner. In addition, we also suggest that students take another one-two year fellowship in a subspecialty to achieve clinical relevance. If we are talking about surgery you can add an additional 3-8 years to this training cycle. This is a tremendous investment in time and resources to produce a practicing doctor who is over thirty years of age before they begin their career.

Can this process be accelerated and can we begin to treat the memorization of facts in medical knowledge like electricity? When we want to turn on a light, we don't check our generator to see if the voltage and cycles are correct. The power company does that for us. We flip the switch and it is there. The electrical power flows to where we need it and we apply it to our task.

Using the singularity paradigm, the intelligent EMR (electronic medical record) provides the data and we train medical professionals to use sophisticated tools to manipulate this knowledge and reason with the clinical facts. Should we not be focusing on clinical problem solving rather than memorization and repetition? Our new singularity tools will bring this discussion to the forefront and open a new window for medical education and innovation. These will be coming discussions that will soon resonate in medical schools around the country.

Although we all wish we had an infinite memory that is not yet feasible and could actually be detrimental in our new medical singularity. The mantra when I went to medical school was that everything you are learning will be changed or false in two to three years. What does that say about our current educational process and our emphasis on memory skills? Is it wise to invest all this time and energy in a single mind that has a limited working window and will someday die with all this information in their head and no way to pass it on. Even a gifted teacher can only influence so many students and his knowledge is only temporary since the student is still forced to use continuing medical education to upgrade his skills as he ages.

This issue is resolved with a singularity of medical knowledge and clinical practice. Everything our expert editorial staff generates and stores in the database is immediately available to all. Those who have great insight and expertise can leave their best information to the next generation through a digital form that has no limitation on access or application. This knowledge does not sleep or have limited working hours, but flows globally at the speed of light and is continually perfected by each new editorial review of the disease or condition.

Before we go much farther, we must draw a clear distinction between medical knowledge and medical wisdom.

Having the right answer to a medical question is a noble goal. However, one could easily ask: "Was that the right question in the first place?" Knowledge is very much like a hammer. It can hit the nail or the finger with equal ease, but one has a very bad outcome. Medical knowledge must be carefully directed and focused by the user or the system so that it returns relevant information. That must be the goal of the singularity engine and will be limited by the database that is used for its information.

The majority of all medical knowledge today is found in books and journals. These documents use written language with medical terms, sophisticated terminology and complicated sentence structure that is often confusing to even the most knowledgeable

reader. Most of these documents are written at a subspecialty level and are not designed for general or even professional consumption. That is why we depend on the peer review process of experts in their fields to condense this content into a set of guidelines (books) that define a disease or a condition so that it can be communicated and learned by another human. Even at this stage, the content is highly sophisticated and not suitable for any computational decoding. Some of the important information is located in tables or graphs and must be integrated into the context of the chapter or book. This requires our medical specialists to read and decode this core "gold-standard" information and reauthor new content for digital application and distribution.

The design of this new singularity database and the structure of the content has taken years to perfect and is now ready for clinical application. This database is the real intelligence in the system and requires dedicated medical specialists to read and translate new medical data into medical factoids for clinical application.

Parsing all this information is critical to create an intelligent interface for the human. Our relational database has the following characteristics:

1. The authoring engine is cloud-based and uses a highly structured interactive format for each author to dialogue with the system. Form, spelling and structure are constantly reviewed and corrected.
2. Each medical factoid is written to provide an eye scan time of less than 20 seconds (speed is critical in clinical medicine).
3. The content is compressed and may appear in phrases or short statements.
4. The medical facts are highly subdivided into categories that relate to medical decision support and the diagnostic and treatment process.
5. The textual knowledge can be merged with visual content to support individual decision support.
6. The authoring process is cloud based and allows a multitude of professional editors to participate under tight editorial guidelines.
7. A final quality control and editing cycle is included in the authoring software to check spelling and content prior to international release.
8. The authoring process is designed to be syndicated into language specific groups that can operate in tandem with the central editorial staff.
9. The medical content of the relational database includes anything that can cause human sickness or disease.
10. The current contents of the relational files include:
    a. A comprehensive dictionary.
    b. Medical synonym files for all the major categories.
    c. Disease files.

d. Drug files.
e. Toxin files.
f. Bioterrorist agent files.
g. Testing and procedure files.
h. Lab/testing result interpretation files.
i. Symptom files.
j. Chart header files
k. Reference files (every fact in our database is based on a "gold-standard" reference and not dependent on any single individual or expert).

II. CLINICAL USE OF MEDICAL KNOWLEDGE

The use of medical knowledge is highly variable and goes from a casual interest in a personal medical problem to a serious condition that is life threatening. The consumers have their concerns and the professionals will have another set of requirements. To address both these groups, the medical knowledge engine will need to be smart and well informed. When you hear medical terms being used there is a strong core of Greek and Latin found in almost every complex statement. This is not a problem for those who have invested years in learning this language, but it leaves the consumer with a barrier that causes them to plead ignorance or indifference.

We must build into any system that is truly intelligent a dictionary and also a synonym table that relates medical terms to common street names. Our database has both of these elements and is constantly learning and growing as the knowledge base is increased. This process will never end and is one of the strong arguments for creating a singularity between medical knowledge and medical practice.

There is also a large collection of similar terms in the professional arena that describes or defines the same item. The intelligent medical database must also know all these terms and allow the system to use them interchangeably depending on the training and background of the user.

If we want our database to achieve singularity it must also be designed for speech. This means that the terms and categories must be structured into: noun, adjective, adverb, and modifier format. All of our medical terminology has been set in this format and is able to be applied in a structured sentence for human interaction.

Since much of medicine is scientific terminology, the translation of our database to another language is simplified. This means that we could use translational engines with human peer review to establish a technology to move from one language to another.

III. **CAPTURING CONTENT AND THE AUTHORS**

Our relational database uses only "gold standard" references as source material. These are the same documents that are used in legal proceedings and can be called as a standard-of-care reference. Our professional medical editors review all these documents and add any new information to our existing files as soon as a new book or journal is released. This continual content review process insures that our materials are accurate and represent the most commonly accepted base of medical knowledge available in the world. The ability to cover all medical specialties and all the new books and journals released in these medial field requires a substantial editorial investment in quality human talent that produces the content for this singularity engine. This content is where the intelligence is resident and it never remains static or stale. The process is real-time and with our publishing engine we can update and refresh all our applications in seconds around the globe.

IV. **MEDICAL CONTENT DELIVERY OPTIONS (www.dxconcur.com)**

The current relational medical library has been used to create both a consumer/professional portal to the KQI database. For medical consultants who are seeking diagnostic support and a second opinion, the web site produces sophisticated tables and charts that can summarize hundreds of related facts and show them in graphical representations using multiple dimensions. This professional application uses a large screen format since the data displays are intense.

This same website has a smart phone and ipad capability that allows tabular data to be delivered to a smaller screen. The goal is to deliver memory-jogging content to refresh the professional's memory and recall skills at the point-of-care. Speed is essential and focused quality content is required.

This same website has a consumer entry point that allows a less intense display of diagnostic information yet provides the same search strategy used in our professional module. The goal is to make medical knowledge accessible to all who have diagnostic/treatment challenges.

V. **MODERN MEDICAL PRACTICE AND EMRs**

We have created an integrated singularity EMR using our relational database. The goal of this development was to demonstrate the advantages of linking an intelligent advisor to the clinical exam room where all the patient decisions are being made. If our technology does not include the patient-physician interface, then we have failed to deliver on the singularity concept. We are not trying to replace or subvert the clinician, but to offer significant advantages over current technology.

Our singularity EMR has over 18,000 disease/conditions that it "knows". It "knows" the symptoms, it "knows" how to interpret these symptoms, it "knows" about the disease and its pathophysiology. It also "knows" what tests are used to diagnose that disease. It "knows" what other diseases look like the primary disease and could be missed in the evaluation process. It "knows" what diseases are secondary to the primary disease and could also be generating symptoms that are not being recognized. It "knows" how to organize all this data and present it in a chart-ready format so that dictation and typing can be minimized. It also "knows" the complete array of symptoms that are found in any condition from the most common to those that are considered rare.

VI. THE CONTINUITY BETWEEN MEDICAL KNOWLEDGE AND MEDICAL PRACTICE

There is a shocking statement which is likely true and also sobering. The time between the creation of a new important advance in medical knowledge and its routine application to a patient is listed at 17 years! Even if this elapsed time were three or four years, this delay is unacceptable. This is one of the critical needs for establishing a singularity between medical knowledge and clinical practice. Each patient should be given the best opportunity to participate in the best medical advice we can offer and to do that we must reach the exam room and the doctor on a real-time basis. This means that we promote a standard-of-care that affects all and provides support for both the most gifted as well the most challenged physicians on the planet. The tools we are describing can empower a consumer as well as a nurse practitioner with the technology to help themselves or their patients on an immediate basis with state-of–the-art technology and medical information. Healthcare is expensive and a wrong diagnosis or poor treatment plan is something we should minimize.

VII. THE SINGULARITY OF MEDICAL KNOWLEDGE AND THE EMR

In our current frenzy to digitize all medical data, the physician has been designated as the keypunch operator for the insurance companies and the federal government. With no incentives or financial reimbursement, the physician and his office staff are under legally binding obligations to make no errors and to comply with all federal "meaningful use"

requirements. The penalties are both financial and jail time. With dwindling payments for charges and increased clerical and administrative overhead, many doctors are closing shop and joining large groups or major clinics. Some are even retiring or going into another profession.

In spite of all these changes, there still remains the goal of making a system that doctors would enjoy using and greatly limiting the administrative time and energy needed to properly care for each patient. Physicians are by nature teachers and they have been raised and trained in a teaching environment. We need to design a new system and a new way of delivering healthcare that makes patient education and physician education simultaneous or singular. Using our current medical technology and the new singularity EMR, we can now accomplish this objective.

1. Our EMR is designed to be shared with the patient in the exam room using large screen projection system technology. This means a redesign of the facility and a sharing of space so that the patient and family can all participate in the diagnostic and treatment process. The same medical record that is shown in the office must also be available to the patient at home so they can discuss their diagnosis and treatment with family and friends. Our system is designed to make this process a reality. Our new multimedia EMR resides on the cloud with encryption and has keys for personal use.

2. Images must be integrated into the medical record so that patient pictures can be added directly to the EMR without clerical support. These images must attach to the right portion of the chart so they can be included in any reports that are generated. With this image handling technology, we can now tap into the wealth of new tools available for the smart phone. We now have otoscopes, ophthalmoscopes, magnifiers, EKG machines, imaging devices, vital sign monitors, cardiac monitors, etc. This list will go on into every possible testing tool so that we have a complete portable physician tool kit for clinical application. All these devices need to be seamlessly integrated into the chart so that the information is stored and chain of custody is maintained. Our singularity EMR does all this and more.

3. Voice dictation is a useful tool and is making major strides in the medical field. Dragon Dictate is a popular application that can run on any EMR and can be used with our EMR. The problem with voice dictation is background noise and a microphone that most physicians find difficult to adapt to their practice. A good compromise is to offer helpful text messages that directly apply to each disease symptom and that can be

modified with simple keystrokes to custom fit each patient. These tools are called "quicklists" and are physician generated and updated.

4. Our system also includes critical factoids about each symptom and its clinical interpretation. These are called " clinical pearls" because they help apply the proper framework for application. These "clinical pearls" are clusters of knowledge that residents spend years learning in their clinical rotations. We have all these permanently stored and available to the physician in the exam room. This is part of our physician continuing medical education program that occurs with each patient at the point-of-care.

5. Our EMR is self-generating and can operate in at least eight different modes:

   a. In the simplest form, our EMR provides no prompts and allows the doctor to add symptoms and create a chart from scratch. This can be a one-liner or as long as necessary. This is essentially a blank piece of paper.

   b. One step beyond the blank paper chart is the "quicklist" option. Here the doctor can build his own list of frequent comments and symptoms to match his practice.

   c. At the next level, we can provide structured charts for a common patient visit such as a camp physical or blood pressure check.

   d. Our EMR can also do a mixed input by allowing any symptoms to be added and then when a diagnosis is reached all those symptoms can be overlaid with our database symptom knowledge about this diagnosis and a composite chart created.

   e. At the next level, we can provide a complete chart structure with all the symptoms and comments attached if the physician will provide his diagnosis. This allows a rapid way of documenting a patient visit with a comprehensive list of symptoms that are seen in the disease under consideration.

   f. As another option, we can review the entire chart and show how well the diagnosis matches the "gold standard" for that condition. This is a numerical analysis. We can also look at all the alternate diseases that look like the stated diagnosis and show how close these alternates match this patient's symptoms. We can also look at all the secondary diseases that can occur with the stated diagnosis and see if any of the symptoms cross over into these new areas. No medical record in the world can do these digital analytical jobs at this time.

   g. At the next level, we can take the complete list of symptoms and patient problems and run an analysis of the entire chart and show what

diseases or conditions could cause this patient's problem. In addition, we can also do a critical analysis of this data and display potential diagnostic possibilities in multidimensional graphics for visual comparison and analysis. This will help select confirmatory tests that could be ordered and visually show how best to eliminate the existing possibilities. No medical record in the world can do these functions. The beauty of having singularity is that all this capability is available at the bedside or in the exam room for any physician using this technology.

h. We can also employ our case analysis function as a auditing tool to retrospectively analyze all the charts for a doctor or practice and offer suggestions if there are any possible alternatives available. This is a creative way for a "digital medical assistant" to constantly keep checking for changes that might modify the standing diagnosis or treatment plan.

6. The new intelligent EMR can also provide a real assistance in maintaining the cumulative patient problem list that was the goal of Dr. Weed in his classic text on "Problem-Oriented Medical Records". This is a central list of all the patient's problems organized by severity: acute, chronic and resolved. This table is the aerial view of the patient's medical problems and should provide the basis for each patient visit. In our fragmented medical care system today, this problem list has been difficult to construct and maintain. With the singularity of medical knowledge, the intelligent EMR and the proper design strategy, this display now becomes a bi-product of the system and requires no additional physician time to operate or use.

VIII. **CREATING THE INTELLIGENT MEDICAL ASSISTANT (AVATAR)**

If we can use our emerging voice interface technology and the AI (artificial intelligence) software that currently exists, our relational database can deliver a very intelligent Dr. Hal for consumer use. This could be as simple as a phone query or as a directed diagnostic interview using a laptop or ipad. In this setting, we are not practicing medicine but giving the patient a good idea of what could be going on and who would be the best specialist to handle this problem. This will result in a direct cost savings since our current triage process is often expensive and unrewarding.

If we can integrate this patient driven information into the patient's EMR, we will be able to feed the medical record system for the doctor who will soon be seeing this patient. A good history of present illness, past medical history and review of systems is critical to

reaching a correct diagnosis and is the entire front-end of any EMR. The patient could complete all these areas in advance and save hours of time in the office. We have designed our EMR to make this feasible and to even integrate into our chart pictures and images taken by the patient. This could be as simple as a skin lesion or even a video of some strange behavior noted in a child. These images are critical to a good diagnosis and may not be possible to duplicate in the office.

We see the extension of this service to professionals in all fields. Digital physician assistants (avatars) could prompt doctors to consider specific tests or ask additional questions based on the full range of possible diagnoses present in each case. It would be like having an intelligent assistant who covers your back and is constantly looking out for your clinical best interests. Doctors don't go into medicine to commit malpractice. Going through a lawsuit is a very emotionally draining and morally destructive experience. Whatever we can do to minimize this possibility will benefit all and make medical practice a privilege and a joy to undertake.

We all know what happens when we get tired or distracted. Mistakes happen and sometimes these can be catastrophic. With a singularity between medical knowledge and clinical practice we can design systems that minimize these possibilities and provide protections that are currently impossible because of the lack of integration and intelligence.

We briefly discussed a case analysis system that is implemented in our EMR that can monitor incoming data and also "rethink" a previous diagnosis. This same service can prepare graphical displays for the doctor to review so that he can see the competing options and get advice on what is the best test or medical question to ask to help limit the possibilities. Just as a professional golfer has a caddy to discuss strategy at each hole, so the physician of the future will have his personal assistant (avatar) to do the detailed clerical work of preparing the patient chart and finding the best alternatives. This leaves the final decision in the hand of the medical professional who now has the best advice and data available for that patient.

IX. **FAMILY MEDICAL RECORDS**

The family is the core of any medical care system and spans the scope from prenatal to senior care. The knowledge of each member of the family and their medical history has to reside in an "intelligent format" so all this data can be processed and used by a digital healthcare assistant (avatar). This requires a way to store and retrieve this information

and one that is totally dedicated to the patient. Our current system has hospital EMRs and doctor EMRs and dentist EMRs and on it goes. There are so many threads that lead to a patient but they do not connect. They are also not under the control of the patient. This leads us back to a patient centered record system that holds the composite file for the patient and is under patient control. We have created this module in "Your Family Medical Record System" that is described on this website.

"Your Family Medical Record System" will hold all the charts and medical information for a single patient and their nuclear family. These files are populated by the patient and it is totally controlled by the patient. Only the patient can authorize access to this file. It sits on the cloud in an encrypted format and will be the base system for our new consumer digital assistant (avatar). The file is device independent and can be directed by the patient as they see fit.

In our current system architecture, Siri or Google voice are device dependent and are not portable across platforms or equipment. What you have in your car is not the same as you have on your phone. It is not the same as the voice interface on your laptop.

Our goal is to make the digital medical assistant truly portable and device independent. At our current state of development, a single operating platform, such as a smart phone, will be sufficient. This will evolve over time and this personal interface will become independent and transportable to many digital devices.

X. **FUTURE DIRECTIONS AND GOALS FOR DEVELOPMENT**

We are at the infancy of artificial medical intelligence and the door is now open to begin to deploy this technology and work out the limitations and inconsistencies. The tools and all the technology is sitting on our doorstep and the expensive/risky development stage has now been completed. The next step is to staff and deploy selected pieces of this process to test for completeness and clinical acceptance. This has to be done in a controlled environment and will need time to perfect. The timeframe is not decades but months.

A recent review of medical malpractice claims and clinical litigation is very helpful in supporting our proposed singularity of medical knowledge and clinical practice. All practicing physicians are required to take risk management courses for license renewal. The latest data from these analytical reviews suggests that: patient communication, test result follow-up and chart documentation are the top areas for improvement. The most recent data (2010) shows that physicians are sued more than any other health professional

(76.8%). In our current environment, family practice and internal medicine are in the top three specialties most sued. The claims against these two specialties are also increasing on an annual basis. Today, a family physician on average can expect a lawsuit every 7-10 years. In 2011, 9,497 malpractice claims were paid in the US with a total expense of $3.1 billion. Based on national malpractice claims data, the most common cause of litigation is a delayed or missed diagnosis (78%). In breaking down this data from several sources on failure-to-diagnose, the studies show that 37-55% of the problems relate to: failure to order the correct diagnostic procedure or test, failure to create a follow-up plan, inadequate history and physical exam, and incorrect test interpretation. There are many issues in medical practice that cause problems, but the consistent theme in all available reports is that the patient sues because they feel the doctor is not telling the truth or is misleading them and the critical patient-physician communication channel has been broken.

Since we now have put the physician on a treadmill by adding more patients, an unintelligent and labor intense EMR and a shorter period for personal contact, this communication problem is not going to improve on its own. That is why we are advocating a total redesign of the patient-physician encounter and the use of visual teaching aids to augment this process. The patient must be moved from a client status to that of a coequal where the goal is to educate and make the patient as self-monitoring and self-vigilant as possible. We need to give the patient the raw data and let him be the best advocate for his future health. Offering medical assistants (avatars) and online support systems will help this process mature and push the emphasis for medical education down to the grade and high school level where innovative teaching systems can be designed so students can learn the skills of medical care and personal responsibility. These are obvious long-term goals, but the achievement of medical singularity will make this process possible.

XI. SUMMARY

The objective of this discussion is to present a real example of singularity in which man and machine can merge and flourish and not be perceived as competitive or confrontational. The EMR is the battle ground of the physician for the next decade and it must be reformed and modernized to make it an intelligent technology that contributes to the overall goal of quality medical care for all.

Bringing the family medical record into this circle now fully empowers our digital medical assistant (avatar) to "learn" and grow with the intimate details of all of the healthcare problems and needs for this medical care group. The ability to learn new

information, pass that to the family and doctor in real-time and to interact with an intelligent advisor opens all the doors for the new world of medical singularity.

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