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Author Note

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Abstract

Quantum computers have recently headlined IBM's next generation of products promoting computational evolution. After the successful launch of the cloud-streaming quantum computer IBM Watson Q, the company has released projections for future development of quantum devices (Fortune Magazine, 2019). Due to the processing power of these machines and the expected integration into everyday life in the near future, these devices will have a substantial impact on the Virginia healthcare field.

I am studying cloud-based quantum computers with natural language processing (NLP) algorithms and patient health record data. My goal is to understand automated, evidenced-based co-optimized treatment of geriatric patients in order to help my reader understand healthcare-centered quantum computer integration in Virginia. I have reviewed academic journals, articles, and reports, some retrieved from medical databases, such as PubMed, to extrapolate the expected use of quantum computers in geriatric healthcare. Exploratory inquiries into these databases included quantum computers, algorithm design, rural and urban healthcare, ethical implications, body-technology monitoring, co-optimized treatment, diabetic glucose polymers, geriatric comorbidities, and expert opinion. Utilizing these sources, I have conducted an academic review of the above research problem.

After conducting the academic review and conceptualizing an optimal system, I stockpiled the unique challenges of geriatric patients to compare to the healthcare treatment and prognosis prediction ability of quantum computers. By locating disparities, such as the underutilization of mass medical data and impersonal SQ GRI, the potential of quantum computer characteristics, such as NLP algorithms and qubit processing, to improve geriatric healthcare was determined. Medical treatment characteristics in both rural and urban settings to better understand CDSS integration in Virginia were analyzed. I have concluded a cloud-based cognitive computing, quantum computer powered multi-health system design that uses natural language processing and mass health data collection has the potential to enhance geriatric patient treatment in Virginia in the near future.

Keywords: quantum computing, quantum computers, medicine, geriatric healthcare, healthcare systems, evidence-based medicine, computer science, Virginia demographics

Introduction

Quantum computers, much like catalysts in a chemical reaction, have the ability to rapidly accelerate (medical) processes. These computers have the potential to ameliorate challenges facing geriatric medical patients. Due to the unique challenges created by diverse populations and geographical factors in Virginia, healthcare administrators can use emerging technology to improve treatment of elderly patients. The growth of unstructured medical data often results in poor treatments for geriatric populations - the use of quantum computers may offer a solution.

The rapidly growing geriatric population generates the largest volume of medical data and places the largest stress on healthcare systems with numerous comorbidities and multifaceted healthcare needs (Divo et al., 2014; Morton & Dunn, 2015; Anderson et al., 2012; Massachusetts Department of Public Health, 2017; International Association of Gerontology and Geriatrics, 2017). Furthermore, quantum computers have adaptable natural language processing (NLP) algorithms, and some models, such as the Google and NASA 1097-qubit D-Wave, have been shown to be 100 million times faster than traditional computers (Herkewitz, para. 3). By studying preexisting clinical decision support systems (CDSSs), telemedicine technology, and cloud-streaming quantum computers (Bujnowska-Fedak & Grata-Borkowska, 2015; Mackintosh et al., 2016; Chang, 2017), it is within reason to believe that a cloud-based multi-health system quantum computer powered CDSS is optimal for integration in Virginia geriatric treatment centers within the next 10 years.

A Beginner's Guide to Geriatrics

According to Sen (2017), a member of a demographic research group at the University of Virginia, one in five Virginians will be 65+ years old by 2030 (para. 1). Due to medical developments that extend lifespan, the baby boomer generation is expected to outlive previous generations which is reflected in age distribution charts of Virginia that show a shift from 12% of residents age 65+ in 2010 to a predicted 19% age 65+ by 2030 (Sen, para. 3, age distribution chart). Because shifting demographics of geriatric populations will place great stress on healthcare systems due to this population's abundant comorbidities and disproportionately large generation of medical data, the industry will benefit from expanding the use of database and processing technology.

The Center for Disease Control reports from a 2016 study that of individuals age 65+, 21.6% are in fair or poor health and of noninstitutionalized men age 65-74, 61.1% have hypertension, and that of noninstitutionalized women age 65-74, 67.4% have hypertension (Center for Disease Control, para. 2,6). Not only do the majority of geriatric patients have diabetes, but the chances of developing comorbidities, two simultaneous chronic health conditions, is 60% for individuals age 65 and up, and 75% for those ages 85-89 years (Day, para. 1).

In a demographic review, Cohen (2009) compared disparities in rural versus urban locations, finding that rural areas most commonly lack staffing. Cohen also acknowledged that geriatrics tend to live in rural areas (pp. 354-355). While no official numbers have been collected, it is within reason to believe that since healthcare systems are the places that geriatrics frequent the most, subsequently producing more paperwork and requiring more medical tests and treatments than other demographics, they generate the largest volume of healthcare data.

A Glimpse into the Quantum Realm

Quantum computers use “qubits” to transfer information and are therefore much faster than traditional desktop computers. The increased processing power will enhance evidence-based treatment for geriatric patients based on collected health data.

According to an analytical study by Solenov, Brieler, and Scherrer (2018), quantum computers operate using the characteristic of quantum entanglement (pp. 464-465). Unlike traditional desktop processors that run as either a 1 or 0, quantum computers have the capacity for simultaneous processing. That is, a qubit (quantum particles, a portmanteau of “quantum” and “bit”) of information transferred inside the computer behaves as both a 1 and a 0 (Solenov et al., p. 465). Therefore, large volumes of [medical] data can be computed simultaneously in a “parallel” manner (Solenov et al., p. 465).

Although most collected health data is lost in a mix of obscurity, Ahmed, Toor, O’Neil, and Friedland (2017) claimed in a predictive research article that quantum computers, such as the IBM Watson Q, can aid doctors in reaching informed decisions because of the exceptional processing power and data storage. Ahmed et al. acknowledged the developing trend of underutilized health data and the impracticality of researchers, students, and physicians to read and understand the material in a timely manner, consequently generating a trail of fragmented data (p. 5). Ahmed et al. noted that doctors, in their human limitations, also fail to consider countless nonclinical conditions that can factor into an individual’s current state such as exercise and eating habits, genetics, and lifestyle (p. 5).

As noted by Ahmed et al., with the projected doubling of clinical data every 73 days by 2020, with an 80% unstructured percentage (p. 5), the volume of medical data is simply too extensive for doctors to make well-rounded, informed treatment of patients. Not only must doctors review patient data, but they will also require 150 hours weekly to review all published content in the field of interest (Ahmed et al., p. 50). Given that there are only 168 hours in a week and physicians must manage time between patient care and newly published research, it is physically impossible for a dedicated Virginia doctor to simultaneously maintain up-to-date medical knowledge and accurate patient treatment analysis. The large amounts of time per data type (research articles, patient data) far exceeds realistic expectations of human absorbance. This overload of data is too excessive to be beneficial to patients and is unfortunately lost among other unstructured data.

The study by Solenov, Brieler, and Scherrer (2018) confirmed the quantum computer benefits and treatment capability hypothesis of Ahmed et al. (2017). According to Solenov et al., quantum computing technology is beneficial in healthcare to detect early onset of cancer, improve surgical accuracy, and to diagnose the sick (pp. 463, 466). Furthermore, Ahmed et al. suggested that the end goal is perfectly customized treatment that lacks human assistance (p. 6). Ahmed et al. noted that growing features, like natural language processing (NLP), learned analytics, and machine emulation of human senses are factors that make great strides towards quantum supremacy (pp. 6-9).

Ahmed et al. emphasized current accomplishments and projects of IBM, such as the IBM Watson Health’s long-term venture with the American Diabetes Society to develop Watson to interpret diabetes data for confidence-ranked prognoses, and added that IBM’s partnerships with Apple, Johnson & Johnson, and Medtronic has similar aspirations (p. 8). Overall, Ahmed et al. contended a future of personalized treatment options and controlled data assessment stemming from the computational power of quantum-driven cognitive computing.

Mighty Mouse

While quantum hardware is located solely in a laboratory setting, some specialists, such as Lee et al. (2017), a clinical instructor in the department of neurosurgery at the University of California, believed, based on knowledge of implantable monitoring devices and current quantum technology such as the D-Wave One, quantum computers have the potential to shrink to cellular size in the near future (p. 405). This compartmentalized version of quantum computers must be specialized for a specific task (Lee et al., p. 407) but has the potential to enhance select treatment delivery, such as SQ (subcutaneous) GRI (glucose-responsive insulin) matrices to diabetic geriatric populations as seen in a 2017 review by Rege, Phillips, and Weiss (p.19).

Rege, Phillips, and Weiss explained the purpose of their comprehensive GRI study was to generate a conceptual model of GRI administration that will permit evaluation of physiological, medicinal, and computational factors to motivate the creation of “smart insulin” pumps (pp. 1-2).

Rege et al. asserted that although some new algorithms have already been developed, multi-factorial, rapid generation of appropriate GRI dosage administration requires more exceptional models, such as those seen in NLP algorithms, because traditional administration of insulin is not regulated by a feedback mechanism. Even with carefully crafted dosing schedules and the use of insulin products, patients with diabetes often experience periods of hyperglycemia or hypoglycemia (Rege et al., pp. 1-2). Furthermore, Rege et al. stated that the optimal SQ GRI balance requires co-optimized treatment to efficiently mimic natural pancreatic β-cells (p. 2).

In the aforementioned review, Lee et al. (2017) commented that “the entire field of modern medicine cannot function without computers” because of the growing disparity between computing needs and neurological computational demands, and to successfully record multi-unit interactions in the brain, large amounts of processing power, data storage, and energy is required (p. 407). According to Lee et al., the neurological computational demand is similar to the challenging stipulations facing quantum computer development and implementation: the need to be small and lightweight, run on a long-lasting battery charge, function with optimized programming, reduce processing power, and demonstrate power conservation ability (pp. 405, 407).

Lee et al. also noted the shift from clinician and patient-operated devices to “smart” devices capable of monitoring and reacting to the body’s physiological processes to attend to patient needs (p. 404). Lee et al. included one such example: the NeuroPace Responsive NeuroStimulator, which monitors for seizure activity deep within the body and is able to respond with electrical stimulation of the brain to reduce neural synchronization complications (p. 405).

As noted in the study of quantum computing powered, cloud-based statistical tools by Marchevsky, Walts, and Wick (2017), IBM Watson Easy Analytics was able to rapidly upload and predict statistical associations from curated data (p. 4). The ability of Watson to handle large quantities of medical data can redistribute time ratios of the patient treatment processes for Virginia physicians. With less focus on tedious medical history, an attending physician now has more time to enhance the treatment of the patient. Some experts, such as Luxton (2019), an affiliate associative professor of Psychiatry and Behavioral Sciences at the University of Washington School of Medicine, shared concerns about emerging technologies eliminating patient individuality, often transforming an ill individual into a name on an X-ray (pp. 134-135, 137). However, Watson can have the opposite effect on physician-patient interaction by promoting individual-focused care for Virginia residents with less physician time spent on analyzing minute details.

Straight-A Student

Cognitive computing includes natural language processing (NLP) algorithms that perform dynamic learning, evolving in intelligence each time the device is used (Ahmed, p. 6). In combination with statistical tools, such as those equipped on the IBM Watson Easy Analytics, quantum-focused software has the potential to interpret large amounts of medical data for individualized predictive analysis and confidence-based treatment recommendations (Marchevsky, pp. 3-4).

Marchevsky et al. (2017) noted in an analysis study of the IBM Watson Easy Analytics that evidence-based pathology draws information in a meta-analysis from literature and personal experience for diagnosis and prognosis, adding that often statistically significant data cannot always accurately predict future conditions (p. 1). Marchevsky et al. stated the research on IBM Watson Easy Analytics studied the system's ability to evaluate and predict patient conditions with pulmonary carcinoid tumors in which Ki-67, a protein marker for cell proliferation (Scholzen & Gerdes, 2000), indices had been confirmed and that the results were compared to traditional statistical software (p. 1).

Marchevsky et al. noted that the definition of evidence-based medicine (EBM) is "a systematic approach to analyze the peer-reviewed literature and extract… valid conclusions… [for] clinical decisions" (p. 1). Marchevsky et al. emphasized that EBM strives to use the best available evidence and claimed use of expert-opinion-based tables have decreased in favor of quantitative meta-analyses (pp. 1-2); the same processing technique used by IBM Watson Easy Analytics.

Marchevsky et al. declared the IBM Watson Easy Analytics is a "smart data discovery service" operated on a cloud-based platform and stated the system was used to analyze a dataset published in a previous study (p. 2). Marchevsky et al. claimed the earlier study immunostained tumors for Ki-67 and assessed under magnification (p. 2). Marchevsky et al. noted hospital records were obtained to gather survival information and the resulting data was analyzed by a professional statistician (p. 2).

Marchevsky et al. claimed IBM Watson Easy Analytics produced predictive survival results of Ki-67 carcinoid patients similar to those concluded in the previous study and was able to self-select tests for the data, concluding the software is appropriate for pathology research and in clinical settings (pp. 4,7).

As discovered in the 2018 utility study of cognitive computing by Patel et al., Watson for Genomics (WfG), a specialized cognitive computing device with functions similar to the predictive tools of the IBM Watson Easy Analytics platform, is capable of predicting cancer prognosis much more accurately than human-curated molecular tumor boards (MTBs) (pp. 179, 184). MTBs are physician meetings where providers collectively advise one another on treatment paths for cancer patients based on the most accurate therapies available (Hoefflin et al., 2018). Similar to prognosis prediction of Ki-67 indices of typical and atypical cases of lung tumor carcinoids used by Marchevsky et al. (2017), cloud software tools powered by quantum computers demonstrate promise in a range of clinical applications (Marchevsky et al., p. 2). From further development of specialized software for research and Virginia physician reference, these tools can be expected to be more accurate and efficient in the near future.

In the academic review of medical-centered quantum computers, Ahmed et al. (2017) reported the average person will produce 1,100 terabytes of health data in his or her lifetime, equating to 300 million books (p. 6). A 2017 health trends report by Stanford Medicine stated the amount of medical data produced is expected to grow from 153 Exabytes in 2013 to 2,314 exabytes in 2020 (p. 8). Likewise, Marchevsky et al. (2017) argued the average physician will be unable to handle the volume of data presented (p. 2) (an estimated 150 hours each week to read all published content relevant to employment concentration) (Ahmed et al, p. 5). The claim of unrealistic expectations of physicians by Marchevsky et al. aligns with Ahmed et al., who claimed human cognitive capacity will continue to remain stagnant; however, the Internet, human genome, and clinical data will continue to grow exponentially in factors per decision (Ahmed et al., pp. 5-6). Because health data is expanding so rapidly, quantum computer-based software made easily accessible on a cloud-based platform has the potential to counteract this growth.

The Need for Speed

Since patients generate a growing amount of information over a lifetime, geriatric populations produce the most data. Due to the large volume of data produced, the elderly population will benefit the most from a computer capable of determining evidence-based prognosis and personalized treatment approaches based on underutilized health information.

Valuable medical data is underutilized, but could make the difference between a life-saving and terminal prognosis. In the study of automated and curated cancer treatment methods, Patel et al. (2017) noted the Watson for Genomics (WfG), the quantum computer specialized for oncology, not only detected 32% more potential significant genomic incidences in patients than a traditional MTBs, but the majority of these detections were deemed actionable based on biomarker-selected clinical trials (p. 179). For precision medicine to function as a co-optimized treatment with MTBs for Virginia geriatrics, Watson needs to not only be accurate, but must rapidly process mass data. Patel et al. also noted that each analysis took less than 3 minutes, compared to an institutional MTB that can vary by physician meeting schedules (p. 179).

Marchevsky, Walts, and Wick (2017) noted that the user-friendly interface of Watson has the potential to streamline this rapid, accurate technology into current Virginia practice.

Patel et al. commented on the clinical data in the oncological field and its growing quantity, even stating "… the interpretation and actionability of somatic NGS results are evolving too rapidly to rely solely on human curation" (p. 179). Patel et al. emphasized concern for the growing disparity between specialist analyses and data volume, even claiming 150,000 of more than 2.5 million scholarly articles published in 2015 directly related to cancer (pp. 179-180).

Cohen (2009), presented a demographic, infrastructural, and cultural review and claimed the trend of shifting workplace populations alters healthcare demand, where a projected 20% of the population will be 65 and older: a demographic that will require more health services (p. 352). Cohen emphasized that population dynamics are significant in increasing the healthcare worker shortage (p. 352). With shifting ratios of labor force and chronically ill geriatrics, the problem is not a lack of medical skill or knowledge, but the lack of care need redistribution that radically alters the Virginia healthcare system.

Hiding the Medicine Cabinet

Intel Health Barometer released the 2013 data that stated only 47% of patients are willing to share health record data, and with good reason (Stanford Medicine, p.17): the US Department of Health and Human Services (2017) health care breach chart revealed hacking was responsible for 75% of healthcare data breaches involving 500 or more individuals affecting 128,620,557 patients (Health care breach charts, 2017). By methodically following legal and ethical guidelines for system integration while treating Watson prognoses as a second opinion, a quantum computer CDSS can be safely implemented in Virginia and patient risk can be mitigated.

In the ethical and legal responsibility assessment of IBM Watson for clinical decision making, Luxton (2019) defined Watson as “augmented intelligence” built to enhance traditional human intelligence and task-performing ability. Luxton noted the large quantities of health records and related data used in the Watson database for patient assessment and reported the system’s typical working procedure: a physician inputs a query, the data is prioritized for relevance, hypotheses are tested, and a confidence-ranked prognosis is produced (p. 132). Luxton claimed Watson may play a key role in the growth of medical knowledge as more information is collected in the database (p. 132).

Luxton concluded that proper implementation of IBM Watson Health requires consideration of ethical implications and systematic measures to reduce patient risks and declared that IBM Watson Health and similar clinical decision support systems will not replace physicians in the future, but assist in the diagnosis and treatment process (p. 135).

Luxton further claimed a generated prognosis, produced in text form, can be provided by Watson (p. 132). Similar to this function, the 2017 supercomputer statistical tool analysis study by Marchevsky, Walts, and Wick (2017), determined the IBM Watson Easy Analytics system, despite its computational complexities, was able to determine population survival associations using “simple language” (p. 4). This simplified user interface encourages [Virginia] doctor utilization, and possibly reduces negligence and malpractice concerns emphasized by Luxton (Luxton, p. 133).

As with implementation of any new technology, challenges will arise. Technological limitations may include fractured or inaccurate clinical data (Luxton, p. 135) and adoption issues, such as ergonomic alterations and practicality (Luxton, p. 135). Additionally, there is a lack of proper physician perception of this new technology because the healthcare industry is prone to the “black-box problem” where users and developers are unable to explain how a system generates conclusions (Luxton, p. 135). Due to the large volume of clinical data, Virginia physicians are at a growing disadvantage for treating patients with evidence-based medicine. If this technology is developed to a capability of understanding relative medical literature to properly function as a CDSS, it may one day be considered unethical to not consult Watson.

Calling for Dr. Watson

A cloud-based cognitive computing, quantum computer powered multi-health system CDSS that uses natural language processing and mass health data collection may markedly improve geriatric patient treatment in Virginia.

In a 2010 systematic review by Haynes and Wilczynski, computerized CDSSs were defined as “information technology-based systems designed to improve clinical decision-making” (p. 2). For practical use, patient clinical data is input into a database, such as IBM Watson Health, and recommendations are quickly generated. While simple in concept, specialists at McMaster University and the University of Washington warn that very thorough evaluations of knowledge translation (KT) is needed for proper implementation of automated decisions systems (Haynes & Wilczynski, p. 2). A variety of complications (black-box problem, fractured data) can have crippling results, such as physician-patient trust violation and malpractice lawsuits (Luxton pp. 133-134).

The Health Information Research Unity (HIRU) at McMaster University has conducted a study of CDSSs, using 87 trials in 2004 (Haynes & Wilczynski, p. 2). Due to the patient-important outcomes, the studies were underwhelming in ability, however researchers claimed that study quality improved over time (Haynes & Wilczynski, p. 2). Similar to how Haynes and Wilczynski's study saw CDSSs develop over time, Brian Lee et al., the neurosurgery clinical instructor at the University of Southern California, extrapolates that quantum computers will follow a similar exponential growth path (p. 405). In fact, Lee et al. claimed: "following this timeline, in about 10–20 years, we will reach a point where the transistor, the basis of computation, can no longer be made any smaller and will reach the level of the atom" (p. 405). Even if quantum computers are not ready for current implementation in Virginia, healthcare systems should expect the rapid growth of technological capability.

CDSSs can be broken down into methodical steps: initially, the user inputs clinical data of the targeted patient, or a curated list is queried from the existing database. The existing knowledge of the CDSS, typically grounded in specialist guideline expertise, uses software algorithms to produce a personalized patient assessment and confidence-ranked recommendations (Haynes & Wilczynski, p. 2). The results are then transmitted to the desired physician, and the healthcare provider determines whether to incorporate the computer-generated data into the medical treatment process (Haynes & Wilczynski, p. 2). It is necessary to find in what capacity technology is ancillary to medical performance, and where the risks outweigh anticipated patient benefit. To acknowledge the limitations of quantum computers, some specialists recommend thorough and strict assessment of implementing systems (Luxton, p.135). This movement towards improved geriatric care is consistent with what Cohen meant in his 2009 geographic and solutions review study when he claimed: "healthcare administrators and program directors need to start immediately and proceed with small but bold steps" (p. 360).

In a 2017 feasibility study of the out-of-hospital, survey-based Multi-dimensional Risk Appraisal for Older People (MRA-O) system in five general practices in London, Walters et al.

acknowledged the recent increase in life expectancy of world populations that places stress on international governments, and further noted the lack of evidence to properly address such large-scale efforts (pp. 1-2). Walters et al. observed that complex interventions have a potential to promote health behaviors and perception, self-efficacy, and independence in older geriatric populations (p. 2).

Walters et al. noted the MRA-O system focused on risk factors using questionnaires, software feedback, and GP (General Practitioner) or nurse follow-ups on a case by case basis (pp. 1-2). Walters et al. claimed the MRA-O system software has the ability to connect health care information and older demographics and concluded a computer-operated risk-appraisal system is feasible for implementation. Walter et al.'s conclusion was based on the system's successful feedback about health and social problems while identifying individual needs in the older populations (pp. 2,9).

Furthermore, to reduce poor physician feedback and unnecessary follow-ups, Ahmed et al. (2017) declared patient-curated communication with doctors is possible if unstructured data is organized (p. 7). As emphasized in the study, messages can be analyzed, and a doctor will be notified if intervention is suggested based on communication patterns that suggest deteriorating health (Ahmed et al., p. 8).

Based on research at Dartmouth College, rural areas are the most vulnerable to healthcare staffing shortages (Cohen, p. 354). With offline processing of Watson Q, a target population can be properly treated, regardless of geography. To bridge the gap, cloud-based computing could reach Virginia populations predisposed to understaffed health systems. However, a significant challenge will be connecting Virginian geriatric patients in remote environments to the Watson Health system. As noted in the 2017 study by Walters et al., a telephone-based risk appraisal system (the MRA-O) is feasible for implementation in geriatric populations. To further bolster this solution, a study by Stanford Medicine (2017) found that telemedical technology is on the rise, with the market for such devices growing from $240M to $1.9B between 2013 and 2018 (Stanford Medicine, p.13).

Not only is the market expanding, but the American Telemedicine Association also reported 1.2 million virtual visits in 2016, with 72% of hospitals already with some form of telemedical devices implemented (Stanford Medicine, p.13).

Conclusion

In light of growth in the quantum computing industry and the expanding geriatric population (Fortune Magazine, 2019; Center for Disease Control, 2017; Day, 2017), Virginia healthcare systems should prepare to expand usage of computational systems and databases. More importantly, if Virginia healthcare systems resist change and implementation of technology, it will unhinge the fundamental value of medicine: the desire to heal. Doctors and medical administrators will be forced to alter the healthcare field's view of what steps are willing to be taken to aid patients.

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