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# Big Data Analytics in Identification, Treatment, and Cost-Reduction of Hypertension

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**Abstract** Hypertension is known as a "silent killer" because patients rarely know they have this deadly disease. Diagnosis is often difficult and can be influenced by factors such as "white coat hypertension" and comorbidities. Most treatment plans consist of modified lifestyles and behavior, and medication when necessary, however many patients do not take medications as directed or consistently. Big Data analytics is the newest method of data processing and management systems for healthcare. It helps determine the most effective treatments, identify patients at risk for hypertension (HTN), suggest treatment plans, and even predict the disease. For providers and patients with high blood pressure, Big Data analytics can be a useful tool for managing data and preventing serious comorbidities and mortality. In this paper, we discuss Big Data analytical tools, HTN, and the use of Big Data in healthcare and HTN.

***Keywords:*** *Big Data analytics, hypertension, privacy, health care, electronic medical record (EHR), data mining, machine learning*

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## 1. Introduction

A report delivered to the U.S. Congress in August 2012 defines big data as "a term that describes large volumes of high velocity, complex, and variable data that require advanced techniques and technologies to enable the capture, storage, distribution, management, and analysis of the information." Some characteristics of big data go beyond size and volume to include variety, velocity, and, specifically to health care, veracity [1]. In today's current health care area, there is an era of open communication; the decade of digitizing medical records has already passed and pharmaceutical companies and other organizations who have cumulative years of research and development as electronic databases are established. Now stored data is usable, searchable, and can be acted on as the federal government and other public stakeholders have increased their data transparency; health care agencies are currently able to access unlimited amounts of data. This increase in data liquidity, together with the development of open communication has brought health care to the tipping point. Stakeholders can now access the promising new threads of data. This data is called big data, identified only for its sheer volume, complexity, diversity, and timeliness. Payors, clinicians, providers, pharmaceutical-industry experts, and other stakeholders are currently beginning to investigate big data usage to gain further insights. These insights, although still in the early stages of utilization, could collectively assist the healthcare industry with variability in quality and the escalating spending healthcare is known for. For example, now researchers can use Big Data to mine the data to determine which treatments are most effective for any given specific conditions, identify any patterns related to drug use and side effects, or hospital readmission, and to obtain even more essential information to help patients and reduce healthcare costs. Although files are huge and often from different databases and have various technical characteristics, fortunately the recent technological advances in the healthcare industry has improved the ability to work with this data. Strong innovators in the private sector, who are both established players and new entrants, are creating applications and tools to help patients, physicians, and other healthcare stakeholders identify cost and prospects [2].

Most providers, for many years, were compensated under a fee-for-service system which only considers treatment volumes, however, not outcomes. Because of this, neither providers nor payors consistently reviewed outcomes data which illustrated how patients respond to treatment. However, because of federal legislation and mandates over the last decade, risk-sharing models are now replacing most fee-for-service models which curb expenses and encourage judicious usage of healthcare resources. Providers are now compensated based on patient outcomes or total cost control. And most payors are entering risk-sharing agreements with pharmaceutical companies to only provide reimbursement for drugs that attain measurable results. Under these new competitive guidelines and shifts in the healthcare landscape, stakeholders now have an incentive to collect and

exchange data, hence big data applications in healthcare. Therefore, payors must have access to outcomes information to determine appropriate reimbursement levels. Providers must demonstrate effective outcomes or otherwise face shrinking amounts of reimbursement and volume [2].

In the current clinical arena, stakeholders are embracing the concept of evidence-based medicine, which means making the best clinical decisions based only on the best scientific evidence available, which Big Data can now provide. In most cases, compiling datasets into Big Data algorithms is the best source for evidence, since distinction in subpopulations (such as the presence of patients with hypertension caused by Pheochromocytoma) could be intermittent enough that individual smaller datasets cannot offer enough evidence to point out which statistical differences are evident. Pioneers in using Big Data are already achieving positive results, prompting other stakeholders to act [2].

An essential tool in assessing a patient's status in modern medicine is the measurement of blood pressure (BP). Indeed, many studies and healthcare organizations have established a relationship between an increased blood pressure and long term morbidity and mortality [3]. However, most patients are asymptomatic. Research has identified an increased prevalence within the aging population and the obesity epidemic. Studies have also shown the control of BP reduces comorbidities, especially cardiovascular disease. The correct position for BP should be either sitting, standing, or supine. The proper size of cuff and technique will increase the efficiency and accuracy of the measurement. In >90% of cases hypertension can be identified as essential, or no known cause. Essential hypertension does have a hereditary component. In <10% of cases, secondary hypertension, there is an identifiable cause; common causes are chronic kidney disease, renovascular disease, street drugs, prescription drugs, natural products, food, or industrial chemicals. The normal BP is <120/80; prehypertension is 120-139/80-89; Stage I hypertension is 140-159/90-99; and Stage II hypertension is ≥160/≥100. There is a phenomenon identified as "white coat hypertension" when an elevated BP is only noted in the clinical environment, however, patients with white coat hypertension may still have an increased risk for cardiovascular disease compared to those without it [4].

Big Data can be used to focus on individuals at high risk such as severe hypertension (HTN), diabetes, chronic kidney disease, and prior cardiac events to yield patient-centered outcomes and improved treatment regimens based on evidence. The most beneficial treatment for mild HTN could be lifestyle changes, which are free of drug side effects and provide extended benefits such as decreased weight, blood sugar reduction, etc. Yet the healthcare system rarely embraces such treatment, and comments are very often made about the lack of adherence to medical advice about lifestyle changes, but it has been identified that 50-80% of patients are non-adherent with antihypertensive medications [3].

Home measurement should strongly be encouraged, which is now possible using smartphones, sensors, and telemedicine which can deliver results directly to the provider and assist in more accurate patient treatment. Current treatment fails patients at considerable risk, who need more attention, and by diverting the resources, many more are failed because a population-based public health approach which attacks the structural drivers of HTN, such as cheap and empty calories, excess sodium and sugars, tobacco and heavy alcohol use, and a sedentary population. As healthcare systems expand and adopt the Big Data method, the idea that medical care can replace population-based strategy has become too appealing [3].

## 2. Objective

Due to the prohibitive cost of hospital readmissions, medications, and insurance coverage among patients with HTN, it has become imperative that clinicians, providers, and stakeholders examine the best way to deal with the data explosion to determine what are the best methods to evaluate, treat, predict, and prevent this "silent killer". It is necessary for stakeholders to grasp the incredible power associated with large datasets. There are several tools that can be used effectively to manage large datasets, but Big Data analytics provides researchers a strong platform for the discovery of correlative data within the enormous datasets most hospital systems now amass ranging from sensors to the EHR, insurance claims, and pharmacy refill records to determine cause, evaluation, prediction, and treatment of HTN. The feasibility of home measurement diagnosis is examined and compared to ambulatory care diagnosis, but the primary purpose of this paper is to introduce the use of Big Data analytics in predicting, evaluating, and treating hypertension among adult populations.

## 3. Methodology

Literature was gathered from several sources including EBSCOHost, Google, Google scholar, and the University of Phoenix library database. Only studies pertaining to big data, big data in healthcare, and hypertension were included in the study. Only articles which included information pertinent to the objective were included in the study. Two researchers examined and verified the data to be included in the study which brought the total number of articles up to 27. The researchers mined the data included in the studies to determine what information was pertinent to the following topics: Big Data analytics, hypertension, and big data in healthcare. Once the data was gathered, articles and data were arranged into suitable subsections of the study.

## 4. Results and Discussions

### 4.1. Hypertension Pathophysiology

Hypertension (HTN) is known as the "silent killer," because more than one-third of patients with HTN don't even know they have it. Most adults will develop HTN after they turn 50 [5]. Blood pressure is generated after the heart contracts against the resistance of peripheral blood vessels and HTN typically results when there is an increase in systemic vascular resistance (SVR) but a normal cardiac output (CO) [6]. An increase in cardiac output generally doesn't cause HTN. Table 1 illustrates the primary causes of HTN [7].

**Table 1. Factors of increasing or associating with hypertension**

| Categories | Non-modifiable factors | Modifiable factors (environmental or lifestyle) | Other factors |
|---|---|---|---|
| Factors | • Age<br>• Family history<br>• Low birthweight<br>• Genetic predisposition<br>• Dark skin color<br>• Susceptible ethnic origin | • Reduced physical activity<br>• Overweight and obesity<br>• Excess salt intake<br>• Unhealthy diet, particularly excess calories, fats, and fructose<br>• Sedentary occupation<br>• Urban living<br>• Excess alcohol<br>• Psychological stress<br>• Smoking<br>• Low folic-acid intake<br>• Low potassium intake<br>• Vitamin D deficiency<br>• Excess visceral (abdominal) fat | • Increased triglycerides<br>• Long-term exposure to noise<br>• Sleep deprivation<br>• Systemic proinfl-ammatory state<br>• High gross national product per head<br>• Undernutrition in childhood<br>• Increased arterial stiffness<br>• Hyperuricaemia<br>• Dyslipidaemia<br>• Prescription drugs (e.g., non-steroidal anti-inflammatory drugs) |

HTN presents a worldwide public health challenge due to the sheer numbers of patients presenting with it and the concomitant risk of cardiovascular and kidney disease. Suggestions by the data include the fact that men and women have a similar overall prevalence of HTN, and increases with age. HTN is a global concern [8]. For the diagnosis and treatment of HTN, there should be two readings at five minutes of rest in the seated position. Research recommends treatment of HTN only after a series of readings over two to four weeks and for patients with only a mild elevation, a series of readings should be utilized to gauge treatment [9].

Research data clearly indicates that patients should be aware of warnings to monitor and regulate BP if they are obese or have a family history of HTN. Lifestyle management strategies, such as reducing salt, losing weight, smoking cessation, exercise, and alcohol reduction should be implemented in any patient with HTN. Medication is necessary for some patients as well as part of a comprehensive treatment plan to reduce BP. Since HTN is a chronic disease, treatments must be maintained for life, however it is not uncommon for many patients to stop lifestyle modifications and medications when symptoms stop [5]. The sheer magnitude of the HTN burden needs not only an increase in awareness, treatment, and control of the condition, but also targeted primary prevention. Population-wide lifestyle changes would result in a lower prevalence of HTN [8].

Although the underlying causes of hypertension are largely unknown, lifestyle and heredity play a significant role in determining who will develop high blood pressure. A survey plumbed these factors by asking respondents to indicate which of the risk factors they have [5]. Table 2 [5] shows the most common risk factors. *n* is the number of survey respondents. There are several options for the treatment of hypertension. They include changes in lifestyle as well as medication. Table 3 [5] shows recommended lifestyle changes based on a survey. Blacks of all ages tend to be more likely to have high blood pressure than whites, but as age increases, so does the gap. Between the ages of 55 and 64 however, the prevalence of HTN among blacks is twice as high as whites. From the age of 75, more than half of blacks have HTN [10].

Annual healthcare costs for patients with HTN typically exceed that of patients without this disease; on average the costs are greater than $5,000 more annually. Unfortunately, expenditures in prescription drugs and hospital stays, including readmissions, account for the greatest difference in costs. Another statistical difference includes the fact that over one half of all adults with HTN have publicly funded insurance, such as Medicare or Medicaid. For patients over the age of 65, almost all patients with HTN have publicly funded insurance. However, although these patients have a publicly funded insurance with little or no copays for medications, one study found that nearly a fifth of all beneficiaries fail to buy their antihypertensive. This failure, however, is higher among patients who have no drug coverage. Big data could be utilized to examine what factors would increase medication purchase among beneficiaries and furthermore, help control HTN among the population [10].

**Table 2. Prevalence of risk factors (*n* = 626)**

| Risk factors | Percentages (%) |
|---|---|
| Have family history of HBP | 54 |
| Am overweight | 52 |
| Have high cholesterol | 27 |
| Live an inactive lifestyle | 25 |
| Smoke | 15 |
| Am African-American | 13 |
| Have diabetes | 6 |
| Have heart disease | 5 |

**Table 3. Lifestyle changes recommended (*n* = 568)**

| Lifestyle changes | Percentages (%) |
|---|---|
| Exercise more | 56 |
| Lose weight | 53 |
| Reduce salt in diet | 49 |
| Quit smoking | 16 |
| Reduce alcohol intake | 11 |

## 4.2. Big Data Analytics in Hypertension and Health Care

### 4.2.1. Big Data Methods and Health Care

The old way of managing data included expensive and small input data from clinical trials, which were small and costly, resulting in an insignificant modeling effort which could take months, since input data is limited and costly. Since the electronic medical record (EHR), data has become cheap and massive amounts of data among a broader patient population has become available. Data is heterogeneous, on a more diverse scale, includes complex use cases, and can be semi-structured, structured, or unstructured. Most of the data in the EHR is semi-structured. Data such as clinical notes, physician progress notes, etc. contribute to a noisy data. There are also imaging data and sensor data to analyze. Data is complex, noisy, and diverse making collaboration across domains, and analytic platforms difficult. Data must be processed (volume, variability, and heterogeneity), and building accurate models for meaningful clinical predictions can also be difficult [11]. Big Data technologies have the potential of providing solutions to these difficult problems in health care.

Big Data can analyze five distinct categories, or streams of information: a) web and social media data; clickstream data as well as interaction data from social media such as Facebook, Instagram, Twitter, LinkedIn, web blogs, health insurance websites, and smartphone apps, etc.; b) machine-to-machine data such as readings from sensors, and meters, etc.; c) big transaction data such as healthcare claims data, billing records, and other unstructured and semi-structured data; d) biometric data such as fingerprints, genetics, handwriting, retinal scans, imaging, and vital signs, etc.; e) human-generated data such as unstructured and semi-structured data in EHR, provider notes, emails, and other paper documents. It has become increasingly apparent that these multiple streams of data sources can be leveraged by these powerful new collection, aggregation, and analytics tools which will not only improve the delivery of healthcare for the individual, but also improve the efficiency of healthcare delivery to disease-specific populations, detect healthcare fraud more readily, and predict disease and disease course. Today, electronic sensors and smartphones with biophysical apps are increasingly employed to monitor in real-time and stream the data to providers in HIPAA-compliant databases. Population health management, quality metrics, management of capitated populations, and treatment protocols can be improved using Big Data tools. Data mining techniques can predict, identify, and help choose the best treatment plan, identify adverse drug events, and reduce waste [12]. Table 4 describes how Big Data is changing the healthcare paradigm [2].

Big Data analytics is an emerging science and technology involving the multidisciplinary state-of-art information and communication technology (ICT), mathematics, operations research (OR), machine learning (ML), and decision sciences for big data. The essentials of Big Data analytics are comprised of mathematics, human interface, engineering, statistics, computer science, and information technology [13]. Table 5 [14] illustrates some primary healthcare uses of Big Data analytics. Big Data analytics includes big data descriptive analytics, big data predictive analytics, and big data prescriptive analytics. They are described as follows [13]:

- Big data descriptive analytics is used to explain the characteristics of entities and relationships among entities within the existing big data. It addresses the problems such as what happened, and when, as well as what is happening.
- Big data predicative analytics is used to create models to predict future outcomes or events based on the existing big data. It addresses the problems such as what will happen, what's going to happen, what is likely to happen and why it will happen.
- Big data prescriptive analytics addresses the problems such as what we should do, why we should do and what should happen with the best outcome under uncertainty.

**Table 4. Big Data is changing the paradigm in health care**

| Five 'Right's | Description |
|---|---|
| Right provider | Care providers (such as nurses, physicians) and setting are most appropriate to deliver prescribed clinical impact. |
| Right innovation | It advances the frontiers of medicine and facilitates R&D productivity in development, discovery, and safety. |
| Right care | Evidence-based care delivers required outcomes for each patient while ensuring safety. |
| Right value | Sustainable methods continuously improve healthcare value by better quality and reduced costs. |
| Right living | Informed lifestyle choices improve well-being and the active engagement of consumers in health care. |

**Table 5. Main healthcare use cases of Big Data & analytics**

| Healthcare use cases | Description |
|---|---|
| Translational research | Identify the genetic basis for diseases in order to help clinicians provide personalized medicine. |
| Biomedical insights, search & discovery | Accelerate data sharing to support research, clinical trials, and new product development. |
| Population health management | Make targeted decisions to enhance care and outcomes on chronically ill patient population. |
| Health monitoring & intervention | Monitor vital changes, raise alerts, and facilitate proactive intervention at home and at the bedside. |
| Analytics for care management & transitions | Facilitate care transitions by identifying high-risk patients and informing an alternative care plan. |
| Consumer insight & engagement | Create a customer-focused view to enable personalized marketing and engagement strategies. |

Data warehouse, statistical modelling, optimization, data mining, machine learning, and visualization are specific methods in Big Data and data analytics [13]. Some characteristics of big data include: volume—which exceeds the physical limits of vertical scalability; velocity—the decision window is extremely small compared to the data exchange rate; variety—numerous different formats make data integration challenging and expensive; variability—there are many options for varied interpretations which confuse analysis. Hadoop is the most visible face of Big Data and includes a MapReduce layer which tracks the tasks. There is also the Hadoop File System (HDFS) which is another layer of Big Data which includes the name node. Hadoop and Cloud systems are cheap distributed storage for processing, include easy accessibility of the external data, and can be revolutionary in disease management [15].

Cloud solutions are being aligned with the healthcare shifts. Cloud allows large scale storing of data and hence flexible Big Data applications can produce merged datasets. Cloud solutions also reduce the impact of IT staff from necessary enterprise software solutions. Technologies such as these are key to improving population health and mitigating risk. Healthcare companies are on integrated platforms to provide a comprehensive continuum of care [16]. Pharmaceuticals also use analytics to try and understand consumer behavior such why they purchase medication, how they feel about their medications, and related behaviors, etc. [15].

#### 4.2.2. Big Data Uses for Treatment and Identification of Hypertensive Patients

The US healthcare system is collecting data from many disparate sources and using Big Data analytics to mine the datasets. Genomics has seen a huge leap in the use of Big Data. Pharmaceutical companies similarly have benefited from the Big Data use as efforts to develop more efficient and effective drugs that target specific diseases. The greatest potential for Big Data in healthcare is through the advantages it gives researchers for insights into the advantages for manipulating the gray data so prevalent today in healthcare. As we see population health expand, Big Data can analyze the structured data from claims containing demographics, diagnoses, dates, cost with pharmacy information, medical and laboratory results, and survey results. Other data that can be analyzed includes physical and socio-economic factors affecting the population, such as health disparities, access to care, availability of nutritious food, and areas that could encourage exercise. We can now measure the health state of any population and devise a metric and unified analytics platform to make improvements in the health of a population through disease management, disease prediction, and better treatment plans which are individualized or tailored to the individual patient, also known as "personalized medicine." Through the elimination of ineffective social programs and replicating the successful ones, we can be sure we are being prudent in utilizing the financial and clinical resources of any community [17].

Old information systems attain data through batch processes before making the data available to the healthcare agency, but with new open source technology such as Apache™ Hadoop®, organizations are now able to quickly acquire, process, and exploit structured, semi-structured, and unstructured data within seconds, rather than at fixed points in the week, month, or year [18]. Developments in digital sensors, communications, computation, and storage have created huge collections of data, securing data of value to business, science, government, and society. There is a rising importance of Big Data computing technologies from advances in many varied technologies; this includes such as sensors—digital data being generated by many different sources; chemical and biological sensors that capture human data such as blood pressure, pulse oximetry, etc.; computer networks—discovering data from various sources that can be collected into massive datasets via localized sensor networks, and the Internet. New methods that include innovations in ways to organize and program such systems include MapReduce programming. Still in the early stages, machine learning is also a method for data management. Still, many algorithms do not scale data beyond a few million elements or cannot tolerate the statistical noise and gaps in real-world data. More research is needed to develop algorithms which apply to real-world data. Automated and semi-automated analysis of huge volumes of data lie at the heart of Big Data computing in all application domains [19].

Today, healthcare consumers can expect increased valued, better quality, and improved outcomes of care at a more affordable cost. The access to unprecedented volumes of data has created an opportunity for deeper insight into disease management, earlier intervention, disease prediction, personalized medicine, and treatment. There is also an increasing demand to connect healthcare to social services creating a driving new partnership. Behavior is now a patient-centered experience which drives an improved outlook and better adherence to treatment. This has set the standard for comprehensive disease modeling [14]. For example, in a dataset, Big Data can be utilized to identify, target, and locate patients with HTN and recommend or mine appropriate, best care, tailored treatment by providers, or predict the disease among those patients located within an EHR dataset who don't even know they have the disease. The benefits of personalized medicine and the ability to mine data from huge datasets for individual disease profiles is priceless. Valuable insights in health lifestyles, lifestyle choices, social determinants, telemedicine, and other clinical and financial factors affecting the health of individuals affect the overall population health. By looking forward to determining who needs treatment when, how, and why, providers can intervene at far earlier times than in the past with a comprehensive treatment plan. This predictive modeling is useful for disease management in HTN because so many patients are unaware of the disease. With smart sensors, smartphone apps that transmit biomedical data, and the Internet of Things (IoT), patients can now be identified far earlier, preventing many sequelae that have increased healthcare costs. Because many patients with HTN are noncompliant with medication regimens, Big Data can be useful to determine these contributing factors and providers and social workers can improve compliance by addressing these factors. Legislation can also be proposed and passed for assistance as well.

Those patients who registered for the post-checkup HTN management services will be given monitoring devices such as a blood pressure meter, a fitness band, a digital scale, etc. The dynamic data gathered from the monitoring devices will be analyzed and a list of variables (e.g. the actual daily amount of exercise vs. the planned daily amount of exercise, etc.) will be mined to reflect the effectiveness of the health intervention plan to fine-tune the models. Further predictive modeling algorithms, which leverage data from IoT devices, to foresee how varied personal behaviors influence health risk change will be instituted. As a result, an intelligent dynamic task of health interventions can be created for a more personalized health management experience [20].

Hypertension can therefore be related more to environmental and lifestyle factors, some genetically defined racial differences, and these factors need to be identified in patient populations and changes encouraged realistically. The end objective of the control of HTN should be the reduction of incident cases of stroke and acute coronary ischemic events. A cost-effective approach should be put in practice to achieve these goals in resource-limited settings [7]. One study identified healthcare workers as being at significantly higher risk of having HTN [21]. Early identification, prevention, and new models of care delivery to improve collaboration among providers, patient knowledge, self-help, and increase health delivery is key to disease management in the current healthcare arena. Published research, EHR, claims data, remote monitoring through *m*Health apps biometric sensors, genomic data, email, text messages, clinician notes, photos, video, metabolomic and microbiomic data can provide cues to intervene and Big Data can mine these applications for valuable insight into disease management. There are many layers of analytics in healthcare to reduce utilization by what providers identify as "frequent flyers" or users of healthcare resources who do so who do so frequently and without thought to cost. We want to reduce the number of those with chronic conditions and those patients who will develop chronic disease over time. Better disease management to reduce long term costs is available through using Big Data. Integration of millions of useful data points from a wide variety of sources and creating separate solutions for factors which prevent getting a holistic view of the patient is key [16].

#### 4.2.3. Privacy Issues and Big Data

A main concern for providers, stakeholders, and researchers in using Big Data is patient privacy; how to ensure privacy is maintained in deidentified data and still allow for effective analysis. How do we ensure privacy yet provide a sufficiently detailed dataset? Much of healthcare data is fragmented, generated in legacy IT systems which are incompatible with other systems, and often very fragmented; it is often diverse and distributed in hard-to-penetrate silos preserved by many stakeholders. Therefore, healthcare providers face significant challenges for implementing analytics, business intelligence (BI) tools, and data warehousing, primarily because man organizations do not want to share their data. While data is often stored in SQL databases, combined with a policy number, any hacker can easily use tools to retrieve unauthorized medical care or bill for services never received. Financial data for the medical industry is fast becoming an easy target for hackers interested in committing fraud. However, behavioral data has increasingly become the favorite for cyber thieves as marketing companies will do anything to obtain data which can drive up sales or other illicit intentions. With the growing use of smartphones, tablets, sensors, and other mobile devices (all these can generate big data), data has become even more vulnerable to hackers [1].

As more information of various kinds become available, stakeholders across the industry also need to protect patient privacy as more data becomes public, ensuring safeguards are in lace which protect the organizations that release the information. Big Data's revolution is in its early days and most of the potential for value creation is still unclaimed [2]. Auditing must be considered then a critical component in any HIPAA compliance program, ensuring patient privacy [15].

### 4.3. Challenges and Trends

Over the past few years, predictive analytics has transformed from an exotic technique to a very competitive weapon for rapidly expanding data usage. Big Data is a tool for improving data analysis, and has demonstrated success in new applications. The predictive models make it possible to make more right decisions, more quickly, and with less cost. Big Data can provide support for human decision-making, allowing models of symptoms and treatment outcomes to become widely used by providers. One challenge for Big Data in today's healthcare arena is privacy. The de-identified data that is analyzed carries the risk of being re-identified and for hackers to break through firewalls to extort damaging or intelligent data for theft [22].

The method for blood pressure measurement can lead to over diagnosis of the hypertension, which constitutes a further concern the diagnosis of HTN. Traditional office based BP measurements by doctors and nurses may be performed incorrectly, unfortunately leading to a misdiagnosis and treatment of a condition which is not accurate. With Big Data analytics, measurements can be analyzed from home and compared to office measurements. With the current research, it appears office measurements should be abandoned altogether in favor of home measurements, transmitted by sensors, telemedicine, smartphones, etc. The appropriate measurement techniques for taking BP should be instructed and tested [3].

Future Big Data-powered systems will become significantly more intelligent by including modules that use image analysis and recognition in databases of medical images (X-ray, CT, MRI) for pre-diagnosis, or modules that routinely mine medical literature to create a medical expertise database proficient in suggesting treatment options to providers based on medical records [1]. Further study on HTN and its comorbidities will more than likely improve the quality of life for hypertensive patients, as well as assist in the prevention of hypertension [23]. Primary hypertension is a comorbidity with relative risks of for diabetes Type I and Type II. To exploit the full potential of Big Data for healthcare the development of new, quantitative methods to extract clinically relevant

information from large datasets of EHRs is necessary. A nation-wide collection of provider and hospital claims data allow the exploration of the health state of an entire country's population with unprecedented precision and scale. First efforts in this direction have proven to be extremely fruitful by developing or improving data-driven comorbidity indices to predict mortality rates, or by studying healthcare utilization and outcome measures of specific patient cohorts [24].

Smartphones can be used to quantify specific data. Big Data analytics can handle the data and apply algorithms to help providers to discover relationships between data and patient. Handling massive amounts of data is vital where smartphones and sensors are concerned and it is necessary to have Big Data to derive the information provided by the copious amounts of data providers may receive on substantial amounts of patients [25]. Although the pervasiveness of non-persistence with antihypertensive medication (complete discontinuation of therapy prematurely) has substantially decreased over the past few years, non-persistence remains pointedly higher in specific sections of the population. Non-persistence with antihypertensive medication is significantly increased, however, in younger patients, men, and among Hispanics. It is also higher in patients with lower incomes, a lack of health insurance, and a failure to consult a provider in the previous year. Patients with a low income (less than $55,000 per year) were almost twice as likely to be non-persistent as those with a higher income. African Americans are at increased risk for cardiovascular disease morbidity and mortality, and more frequently progress to end-stage renal disease when compared with other ethnic groups [26]. The occurrence of relationships among significant comorbidities could provide useful insight into describing the disease development process, resulting in an increase of the provider and patient awareness at the early stage of development [27].

## 5. Conclusion

Hypertension is a growing problem for patients in various sub-populations, specifically the African-American population, low income population, and those without healthcare coverage. Data indicates that diagnosis of HTN based on office measurements only may result in misdiagnosis or treatment of a non-acute condition. Large amounts of data must be examined over a period of time to determine the feasibility of home-based diagnosis for HTN and other factors related to HTN. Big Data analytics has shown that home measurement is most often the best choice to determine disease and make diagnosis. However, it is extremely important for patients that the blood pressure measurement is appropriately done, without causing a higher-than-necessary measurement of the blood pressure. Data in enormous amounts from the EHR, human-provided information, and omics, must be analyzed to completely understand the diagnosis of HTN and give providers the ability to predict the disease as well as tailor treatment plans specifically for the patient. And unfortunately, providers are not able to ensure patients are compliant with lifestyle modifications or prescribed medications so the use of big data may provide suggestions for improving this. Pharmaceutical companies are striving to make sure patients do get their medication by using Big Data analytics to promote awareness and research. With the advent of Big Data analytics, providers can access and make sure they can understand the massive amounts of data that patients may produce, whether through biometric devices, telemedicine, sensors, or smartphone apps. Given the comorbidities associated with HTN and the mortality rate, it is vital that providers continue to utilize novel methods of data management, including Big Data tools to stay informed and account for patient data. Privacy still continues to be an extremely important area for consideration as data becomes warehoused and accessible, However, studies show that Big Data is still more useful than older data management systems.

## Statement of Competing Interests

Authors have no competing interests.

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