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## The Effects of a Healthcare Chatbots' Language and Persona on User Trust, Satisfaction, and Chatbot Effectiveness

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THE EFFECTS OF A HEALTHCARE CHATBOTS' LANGUAGE AND PERSONA  
ON USER TRUST, SATISFACTION, AND  
CHATBOT EFFECTIVENESS

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A Thesis  
Presented to  
the Graduate School of  
Clemson University

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In Partial Fulfillment  
of the Requirements for the Degree  
Master of Science  
Industrial Engineering

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by  
Courtney Katherine Linder  
May 2020

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Accepted by:  
Dr. David Neyens, Committee Chair  
Dr. Kapil Madathil  
Dr. Jamiahus Walton

## ABSTRACT

Healthcare technology is growing in its capabilities and capacity to impact people's daily lives. One area of interest for growth is the use of chatbots and other telehealth applications that allow people to receive ubiquitous health information. The benefit of these systems is the ability to give access to pertinent, personalized healthcare information and services that could otherwise be inaccessible for some populations. With personalized information, patients may gain the information needed to make efficacious healthcare decisions which ideally will result in quicker recovery times and lower overall healthcare system costs. Chatbots have already been studied in the healthcare domain as resources for smoking cessation, diet recommendation, and other assistive applications. Yet, few studies have examined the specific design characteristics of healthcare chatbots. My research objective was to analyze two characteristics, language and persona, and their effect on outcomes such as effectiveness, usability, and trust in a chatbot. A between-subject study was performed where participants interacted with a chatbot. Each of chatbot conditions had a language of either technical or non-technical, and persona of Doctor, Nurse, or Nursing Student Sarah. Language was found to have a significant effect on effectiveness, but not trust or usability. In particular, participants who experienced technical language improved significantly greater than those who experienced non-technical language. Persona was found to not be significant for any of the outcomes. Overall, this study demonstrated a need to further study and understand how chatbot design characteristics impact users and how they comprehend the information given to them, particularly from a healthcare perspective.

## DEDICATION

I would like to dedicate this thesis to my grandfather, affectionally known as Bubba. His support and encouragement through my education process, and that of all his grandchildren, has been unconditional. Thank you for all you have done for me and the family financially, emotionally, and spiritually, Bubbs.

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## CHAPTER ONE

### INTRODUCTION

As modern technology such as computers developed in the 1960s and became more prominent in the 1980s, there was a shift in healthcare to integrate computers and phones into the healthcare process. This integration included using computers for health records, automated messaging services, and patient portals for individuals to be able to view their health charts electronically. One systematic review that investigated the benefit of mobile-health technologies on service delivery processes found text message reminders had a modest benefit in increasing clinic attendance (Free et al., 2013). Another systematic review found a mild to moderate positive effect of a home-based telehealth system on clinical outcome of care (DelliFraine & Dansky, 2008).

Of the many technology advancements in healthcare, one of the most noticeable is the integration to manage healthcare records. Today, these systems are known as health information technology (HIT) and they enable physicians and hospitals access to electronic health records for each patient. HIT has benefits on administrative functions as well as on practitioner's performance (Jamal, McKenzie, & Clark, 2009). HIT decreases what would normally be "paperwork" tasks as well as administrative workload, increases efficiency for administrative practices, and decreases administrative errors which can result in a decrease in costs (Hillestad et al., 2005; Jamal et al., 2009). Going beyond the administrative benefits of HIT, Jamal et al.'s (2009) systematic review of HIT effects on practitioner's performance found significant results. Of the 17 studies that assessed practitioner's performance, 14 studies showed a significant increase in physicians'

compliance with evidence-based guidelines when using HIT. This compliance to guidelines included compliance to recommended drug type and dosage. It is also important to note in the review it mentioned the success of these systems was related to proper design. This designation is crucial as technology can be a barrier to success if designed improperly.

Improper integration or design of technology into healthcare can introduce complications to process, practices, and system outcomes. Kim, Coiera and Magrabi (2017) performed a systematic review of technology's effect on care delivery and patient outcomes, and discussed technology that has been linked to patient harm and death (Kim et al., 2017). Issues with technology range from problems with interface mistypes or misunderstandings to incorrect information auto-populated into fields such as drug dosage (Kim et al., 2017). The most common error was commission type where the data was entered or selected incorrectly. This type of error can lead to a negative alteration of a patient's care with examples like an increase of dosage or receiving the wrong medication. These kinds of technology issues may lead to providers using workarounds to avoid problems. These workarounds, formed because of improper designs, can be helpful to accomplish the task at hand, but overall defeat the purpose of the technology. Therefore, workarounds may be useful for the immediate context, but they demonstrate a need for better technology creation as it allows for human error to enter the system.

However, technology is only becoming more common place and thus the pitfalls of technology will become more common place. A systematic review by Coiera, Ash, & Berg (2016) evaluated unintended consequences of technology in healthcare. The authors

discussed varying results for an implementation of the same computerized physician order entry system in hospitals across the country in places such as Pittsburgh, PA, Seattle, WA, and Palo Alto, CA. In Pittsburgh, pediatric intensive care unit mortality rate increased from 2.8% to 6.6%. In Seattle, there were non-significant results with mortality rates going from 4.2% to 3.5% while in Palo Alto there was a significant decrease in mortality rates (Coiera et al., 2016). This disparity was “most likely due to differences in implementation processes including clinical workflow, speed of implementation, and staff training” (Coiera et al., 2016, p. 165).

Regardless of the potential barriers to implementing technology in healthcare, there are a number of potential situations that existing technology may further improve or may be useful in supporting patient care. A few areas of interest for technology growth in healthcare include interactive electronic health records, health decision support systems, healthcare chatbots, health education programs, advanced telehealth applications, and ubiquitous health information website (Kreps & Neuhauser, 2010). With approximately 90% of the US using the internet (Clement, 2019), there is opportunity for healthcare technology to be utilized by people in their everyday lives. Kreps and Neuhauser (2010) discussed the potential for eHealth communication to be customizable, enhance user control, be interactive, and allow for social networking. Of these, the opportunity for customization and individually tailored health care information is crucial for patient control of decision making and information seeking.

Iverson, Howard, and Penney (2008) investigated online health-seeking patterns and found that 58 percent of patients used information they found online for

understanding their health problems. These patients reported asking more questions during their office visits, followed physician advice more closely, and made self-directed dietary changes (Iverson et al., 2008). In another study, Nijland et al. (2008) found that patients and caregivers wanted the health website to be easier to navigate and offer more personalized information so they could make better self-care decisions. This desire for personalized healthcare information and control of making healthcare decisions allows for opportunities to assist patients and their healthcare goals.

### **Chatbots potential for individualized communication**

Chatbots are one potential user-centric technology solution for offering more personalized healthcare information, creating interactivity, and allowing more control with healthcare decisions. Chatbots are typically used to enable communication between a person and an artificial agent. When it comes to designing a chatbot, there are certain paradigms it must fit to be considered a chatbot. Chatbots receive natural language input and execute computer commands to engage with the user to accomplish a goal (Abdul-Kader & Woods, 2015; Fadhil, 2018). The structure of chatbots can range from a type of pattern matching, which fits a user input to a response, to artificial intelligent (AI) chatbots, which can respond more naturally and learn to respond better with time and use. Chatbots are typically not embodied by a virtual agent or avatar. Such applications tend to be considered embodied conversational agents and have their own set of criteria for design (e.g. visual cues, audio) (Radziwill & Benton, 2017). The consideration of what type of chatbot to design will depend on the environment in which it will be used, the capabilities of the chatbot created, and the tasks of the user. The user's tasks when

interacting with a chatbot are usually goal oriented or general knowledge seeking (Fadhil, 2018).

The first introduction of chatbots was to test a set of criteria developed by Alan Turing. Turing developed a set of criteria (known as the Turing test) to evaluate if a robot could be indistinguishable from human (Turing, 1950). The Turing test has been used to provide some indication of the ‘realness’ of a robot. The first chatbot, known as ELIZA, was tested with these criteria and interacted as a psychotherapist (Weizenbaum, 1966). While acknowledged for its computing complexity and ingenuity, it was still rudimentary in its ability to have true discourse. As a psychotherapist, its main goal was to keep the user “talking” on subjects the user wished to discuss. It used a pattern matching technique where it would take input, find key words, and ask the user to continue on that line of thought. For example, if a user mentioned going for a boat ride, the chatbot would ask the user to tell it more about boats. Regardless of this conversation simplicity, it was able to produce strong emotional responses in people by creating an emotional connection (Weizenbaum, 1966). Compared to today’s chatbots that can use more complex pattern matching techniques as well as artificial intelligence to improve upon its answers, earlier chatbots worked primarily because of the speaker’s contribution to the chatbot. The chatbot could engage in follow-up-questions to keep the user “talking” but could not necessarily learn from the conversation. Modern chatbots’ ability to offer information on a range of subjects goes beyond just asking for information with the ability to search the web, provide updated information, and learn from its experiences. These newer forms of chatbots are helpful for a wider assortment of purposes.

With applications such as Apple’s “Siri”, Google’s “Google Now” and Amazon’s “Alexa”, the use of chatbots and conversational agents in daily usage is growing. These more recent applications are an evolution of the first chatbots and can facilitate two-way real-time communication using smart phones or computers. A huge shift in the way in which we communicate, along with the rapid change of technology capabilities, is partly responsible for the rise of chatbots. In retail for example, people are turning more towards chatting over calling for the ease of asking question with continuous access and quick response time (Galert, 2018). In 2016, Facebook Messenger alone had over 100,000 chatbots in use to connect with customers (Galert, 2018). A common application of commercial retail chatbots is to discuss frequently asked questions and assist with common operations concerning a product. For example, returning merchandise bought on a retail website or submitting a complaint on a service can be handled by a chatbot. One study that investigated a chatbot’s effect on marketing brand and customer service was positive even if the chatbot could only converse in a limited capacity with the user (Chung, Ko, Joung, & Kim, 2018). Their results showed that the chatbot increased customer engagement, provided continuous availability, offered customizability, and gave simple and natural customer experiences. Another retail study investigating a chatbot’s effect on the brand’s image had results that showed how consumers think as well as how they feel about chatbots significantly influence the effectiveness of chatbot technology (Zarouali, Van den Broeck, Walrave, & Poels, 2018). The study also found design differences changed depending on the chatbot’s task and need to accomplish different goals (Zarouali et al., 2018). Some examples they provide is for a company to

include jokes or emojis to increase pleasure, quick and time-efficient responses to increase usefulness, or more detailed and relevant information to increase helpfulness (Zarouali et al., 2018).

Applications for chatbots can assist various products and services including business, education, entertainment, and healthcare. Some examples include weather chatbots to inquire about current and future weather conditions, business chatbots that can offer recommendations for what to eat, or an embodied conversational agent known as Max that was a museum guide (Kopp, Gesellensetter, Krämer, & Wachsmuth, 2005). In Kopp et al. (2005), they used measures such as surveys to gather data on people's perspective of the museum guide. Their results yielded promising evidence for Max's ability to engage visitors in social interactions and create a dialogue.

Other chatbot applications investigated using chatbots as tutors (Abbasi & Kazi, 2014; Jia, 2003; Latham, Crockett, McLean, Edmonds, & O' Shea, 2010). In Latham et al.'s (2010) pilot study, they found promising data for a chatbot's ability to tailor its teaching to the needs of the student, but no formal conclusions were drawn due to the small number of participants. Abbasi and Kazi (2014) studied another tutor-like chatbot on a student's learning and memory retention. The researchers wanted to see if learning was better when using a chatbot versus learning via Google searches. Using a repeated measures design, the researchers examined learning and memory retention after five minutes, two hours, and one day using knowledge tests (Abbasi & Kazi, 2014). The learning outcomes for understanding a particular subject were positive for both groups; however, the outcomes in the chatbot group was significantly higher than that of the



Google group for all three periods. In another chatbot as a tutor study, the researchers looked at the use of a chatbot as a way to teach foreign language (Jia, 2003). This study found that the repetitive nature of a pattern matching chatbot was not similar enough to real English language and syntax to be able to teach it effectively. The machine did not truly know English and as such could not teach it.

### **Data bias concerns**

When it comes to integrating into society, chatbots have experienced their own problems particularly with data bias. A well-known example of a chatbot failure was Microsoft's Tay, as noted in the Washington Post and other news outlets (Ohlheiser, 2016), that was released in 2016 and within 24 hours had to be taken down. The chatbot was supposed to learn how to respond from interactions on Twitter but it inadvertently became very offensive and controversial when users targeted the platform's vulnerabilities. Another example of a chatbot bias failure was Amazon's AI resume reviewer (Dastin, 2018). This tool was meant to make recruiting employees easier for one of the largest companies in the US. Unfortunately, there was a huge flaw in the design of the system, by favoring male applications over female applications because the training data was male dominated. The tool was used for over 2 years for recommendations before the problem was fully recognized and the system taken down. These examples demonstrate some ways in which chatbots can fail, including how the interactions with the users affect the chatbot and the chatbot's vulnerabilities based on the designer's assumptions and initial development (e.g., training data set samples).

The bias in data used by chatbots is a critical concern. Potential biases are of particular concern in healthcare as providing recommendations for health-related actions or treatments needs to be individualized and not based on a potentially biased sample or be influenced by misinformation available on the internet. For example, some trials for drugs and health information have only included male participants and as a result other groups tend to be disproportionately represented (Liu & Dipietro Mager, 2016). One example of biased healthcare data is the symptoms for a myocardial infarction. In some cases, men and women experience different symptoms, and therefore women experiencing myocardial infarction often go undiagnosed and untreated (Beery, 1995). In fact, while a myocardial infarction brought on by heart disease is more common in men over 60, the same condition for women over 60 results in more deaths due to unrecognized conditions and delayed care (Global Health Observatory (GHO), 2019). As technology advances in healthcare, we must gather better data to be inclusive and facilitate the inclusion of representative populations so that when chatbots answer questions about health, they can relate it to their specific user demographics (e.g., age, race, gender, access to health resources, socioeconomic characteristics) and the impact of comorbidities.

### **Chatbot applications in healthcare**

In healthcare settings, chatbots have been used and researched in different capacities. Currently, healthcare chatbots have been implemented to help with everything from diets recommendation (Fadhil, 2018) to smoking cessation (H. Wang, Zhang, Ip, & Fai Lau, 2018) to cognitive behavior therapy (Fitzpatrick, Darcy, & Vierhile, 2017). The

social aspect of chatbots have been shown to help support people with online groups for various health conditions (Kumar & Ros, 2014). One chatbot was tested as a source for young adults to ask sex, drug, and alcohol related questions which allowed teenagers to ask such questions without judgement and learn important information regarding sensitive subjects (Crutzen, Peters, Portugal, Fisser, & Grolleman, 2011). The chatbot's ability to offer anonymous and private access to information on such subjects may have major health implications to be further explored.

Additionally, chatbots ability to help users gather information on various subjects has been shown to help low healthcare literacy populations more effectively than regular browser searching (Bickmore, Utami, Matsuyama, & Paasche-Orlow, 2016). This subset of the population accounts for 35% of the US population with basic or below basic healthcare knowledge and disproportionately affects low income areas and ethnic minorities (Office of Disease Prevention and Health Promotion, 2003). Readmission rates for common diseases among low income areas tend to be higher than the national average (Manickam, Mu, Kshirsagar, & Bang, 2019). Therefore, there is potential for healthcare chatbots to address low literacy populations in low income areas by assisting people in understanding their healthcare needs and allowing for ownership over their healthcare decisions. Chatbots offer an affordable and accessible solutions to patients regardless of demographics. Even if patients do not have a computer to access the chatbot on the website, the chatbot could be extended to communicate with people over texts. As was mentioned earlier, Kreps and Neuhauser (2010) found that the customizability of healthcare information is crucial for patient understanding and decision making. This

customizability is especially important in making sure the information matches people's literacy level. Health literacy is important in empowering people to manage their health (Boren, 2009). One study that looked at discharge instructions found that with improved readability and formatting, there was improved performance as well as improved comprehension for both the patient and caregiver (Vaigneur, 2015). Part of the formatting included lowering the reading text level for the discharge instructions. The lower the level of language used, the lower the mental demand on the caregiver and patient. Yet, most health information is written at levels that exceed people's understanding (Canadian Council on Learning, 2007). This health literacy issue does not come without a price. The costs to the US healthcare system associated with low health literacy is estimated to be between \$106 billion to \$238 billion annually (Bonet & Sasangohar, 2019; National Network of Libraries of Medicine, 2019). The chatbot's ability to offer accessible, personalized information for low income areas may have health literacy and thus healthcare implications which needs to be further explored.

One study investigated a virtual counselor to collect family histories and found that a virtual agent speaking out loud was able to assist low health literacy populations more effectively than regular text (C. Wang et al., 2015). While the application is more of the embodied conversational agent instead of a chatbot, the research performed in this study was consistent with some of the ideas which this study hopes to accomplish. The study examined how participants' health literacy possibly impacted the perceived usability of the virtual agent as well as the information understood by the participants. The participants were organized into two groups, those who interacted with the virtual

agent, and those who interacted with the normal healthcare patient portal. Drawing reference from this study will help structure the research accordingly.

### **Issues with chatbots in healthcare**

A potential drawback to using lower level language, or non-technical language, could be a lack of trust in the information or the chatbot being perceived as not having the correct information. One study that investigated the use of informal language for online counseling found counselors who used informal language when their client used formal language were perceived as having less expertise (Haberstroh, 2010). When the students and the counselor both used informal language, the students were less critical of the counselor's expertise. Additionally, attractiveness and trustworthiness were measured and found to be non-significant between the conditions. To design a healthcare chatbot properly, the use of technical or non-technical language needs to be studied. If users do not trust the system or think the information is false, then the information may not be utilized and therefore be ineffective. If technical language is too difficult for people to understand, that could also cause problems in healthcare information understanding and be ineffective.

### **Research objective**

The focus of this research was to evaluate the effect of technical and non-technical language as well as the presented qualifications of a chatbot agent (e.g. doctor, nurse, nursing student). Few, if any studies in the literature have investigated the effects of a chatbot's language in a context such as healthcare in conjunction with a chatbot presented qualifications or persona. The expectations and needs of a healthcare chatbot

may be different from chatbots used in other industries. It has been shown that there are different effects of language and communication style for a chatbot used in a retail setting (Elsholz, Chamberlain, & Kruschwitz, 2019). Specifically, Elsholz et al. (2019) found that while a modern chatbot using regular English was rated as being easier to use, a Shakespearean style chatbot was rated as being more engaging and increased the value users placed on the product. The goal of our study was to examine the effect of an educational healthcare chatbot on user's satisfaction via usability, knowledge gained, and trust in the information based on the language used by the chatbot and the persona of the chatbot. To access the chatbot, we used verified surveys and metrics that determine usability, trustworthiness, and effectiveness of chatbot technology (Corritore, Marble, Wiedenbeck, Kracher, & Chandran, 2005; Lewis, 1995; Radziwill & Benton, 2017). We also evaluated whether there is an interaction between title and language used.

## CHAPTER TWO

### RESEARCH DESIGN AND METHODS

#### **Design of study chatbot**

The chatbot used in this research resembled more of a pattern matching chatbot rather than an artificial intelligence (AI) one. Pattern matching is when there are set answers to questions and the question patterns match to certain answers patterns. For this study, there were predefined answers that offered the same information in technical and non-technical language that the experimenter delivered as a response to questions asked by the participant. This type of experiment, where the user performs an action they think is controlling the system response but in reality a separate person is controlling the response, is known as Wizard of OZ and has been performed in several studies (Jurewicz & Neyens, 2017; Jurewicz, Neyens, Catchpole, & Reeves, 2018; Morris, Wobbrock, & Wilson, 2010). Our Wizard of Oz structure simulated the chatbot with the experimenter controlling responses. The study had the user perform general knowledge seeking for health information on blood pressure. In Kim et al.'s (2017) review, the most common purpose of chatbots in healthcare was to provide education and training for conditions like mental health, type 2 diabetes, breast cancer, hypertension, asthma, pain monitoring, and language impairment. This common use of healthcare chatbots is why the focus for the healthcare chatbot used in this study was on general knowledge gathering for a specific subject instead of focusing on specific tasks to be completed.

Another aspect of the chatbot which needs to be considered is the latency of responses or how long it takes to respond. If a computer takes too long to respond, a user may be inclined to not trust the computer or think it is not effective (Rogers, Khasawneh, Bertrand, & Chalil Madathil, 2017). To manage this, the experimenters told the participants that the chatbot and website were in the developmental stage and as such, the chatbot could take up to 30 seconds to respond to a question. Through pre-testing with students in the Clemson EASt (Ergonomics & Applied Statistics) Lab, it was also determined that responding too swiftly was startling and unrealistic. In respect to trust from this angle, the chatbot cannot respond too quickly. It was determined through the pre-testing to wait approximately 7-10 seconds before responding if an answer was found speedily from the Word documents.

### **Pre/post-test creation**

A test was created to assess participants' blood pressure knowledge before and after interacting with the chatbot. The same test was used as both the pre-test and the post-test with even the order of the questions remaining the same between tests. The pre/post-test evaluated how much participants improved their blood pressure knowledge after interacting with the chatbot. It also indicated if any participants had usually high pre-existing blood pressure knowledge via high pre-test scores, which could create potential biases in the analysis when looking for improvements. To create the test, I read through blood pressure books and online sources to understand more about blood pressure and common misconceptions (Childre & Wilson, 2006; Galton, 1973; Kaplan & Lieberman, 1979; Wade, 1975). I also reached out to an intensive care unit (ICU) nurse to



ask her about frequently asked blood pressure questions and frequently misunderstood blood pressure ideas. I used the information I learned to create a quiz containing 21 blood pressure questions. Once created, I piloted the quiz with my Clemson EAST (Ergonomics & Applied Statistics) lab members. I had them look over the pre-test and do their best to answer each question. I then had my lab members discuss which questions needed improved or could be removed as well as what kinds of questions they would ask based on this pre-test. Performing the review session allowed me to improve my test, not only by rewording questions and answers to be more specific, but also by removing questions that were deemed unnecessary. In total 16 questions remained for the final version of the test. The pre/post-test is shown in Appendix A. Additionally, through the pilot testing and review session, I was able to gather more information on possible participant questions which allowed me to create more chatbot responses. The construction of these chatbot responses is discussed in the following section.

### **Preconstructed response creation**

Responses to possible participants questions were created, evaluated, and refined through pilot testing and reading blood pressure information online and in books (Childre & Wilson, 2006; Galton, 1973; Kaplan & Lieberman, 1979; Wade, 1975). The test was created with an initial list of questions based on the pre-test and the above resources. The responses were created to those questions along with other possible generic question response. A review session with my lab members where they took the pre-test and then offered suggestions for test improvements as well as questions they would ask after finishing the test. Taking these suggestions, more responses were created for a greater

range of questions. The chatbot responses were formatted to answer the questions, starting with technical language. Generic responses were also created. One example of a generic response is, “I am sorry, I am unable to answer that question. Do you have another question about blood pressure?” These generic responses accounted for unanticipated questions for which I had not prepared. The generic responses did not change between technical and nontechnical conditions.

With the additional responses constructed, pilot testing was done with the same lab members. This time, the lab members performed the entire study procedure as if they were actual participants. They went through the surveys and then interacted with the chatbot for 10-15 minutes. Through this process, more questions were identified that could be asked to once again improve the chatbot’s answering capabilities. Additionally, it provided practice for the Wizard of Oz structure of controlling the chatbot’s responses in a reasonable manner and gave a better understanding of what to expect from participants. The pilot testing helped showcase patterns of how participants may ask questions and helped determine a format for the preconstructed responses to be in easily accessible categories.

To transition between technical and non-technical language responses, the responses’ reading levels were assessed via the Word reading assessment feature. This feature utilizes the Flesch-Kincaid readability tests consisting of the Flesch reading ease and the Flesch-Kincaid grade level to assess the reading difficulty of the text. These tests were created in the 1970s and used by the military to assess technical manuals and are still used today to assess manuals, legal documents, and insurance policies (Linney, 2017;

Williamson & Martin, 2010). The non-technical responses all had high reading ease, which was desired, and a reading grade level of 8 or below. Due to the use of some medical terms like systolic and diastolic, which could not be replaced, there were certain answers which could not be reduced any lower than an 8<sup>th</sup> grade reading level. The 8<sup>th</sup> grade reading level was then used as the standard for the non-technical responses as the maximum level. Some responses were able to be reduced as low as 5<sup>th</sup> grade reading level. As for the technical responses, they had low reading ease values, which was desired, and grade levels of 12<sup>th</sup> grade or higher. While one possibility to increase the levels could have been to add additional text or information, this could not be done because there needed to be consistency between technical and non-technical responses in terms of what information was given. This consistency is to make sure one group did not receive more or different information from an answer than the other group. Having this consistency helped avoid confounding factors in the experiment. Therefore, the lowest grade level for the technical group was 12<sup>th</sup> grade. The highest-grade level technical response reached a 20<sup>th</sup> grade reading level. See Appendix D and E for the technical and nontechnical answers respectively.

### **Study design**

The experiment was a 2 x 3 between subject design where each of the 6 conditions was experienced separately by each participant to avoid a bias from learning about blood pressure in a previous session. Table 1 shows the layout of the study design. The results were analyzed using generalized linear regression model principles.

**Table 1: Study design and the expected number of participants per condition**

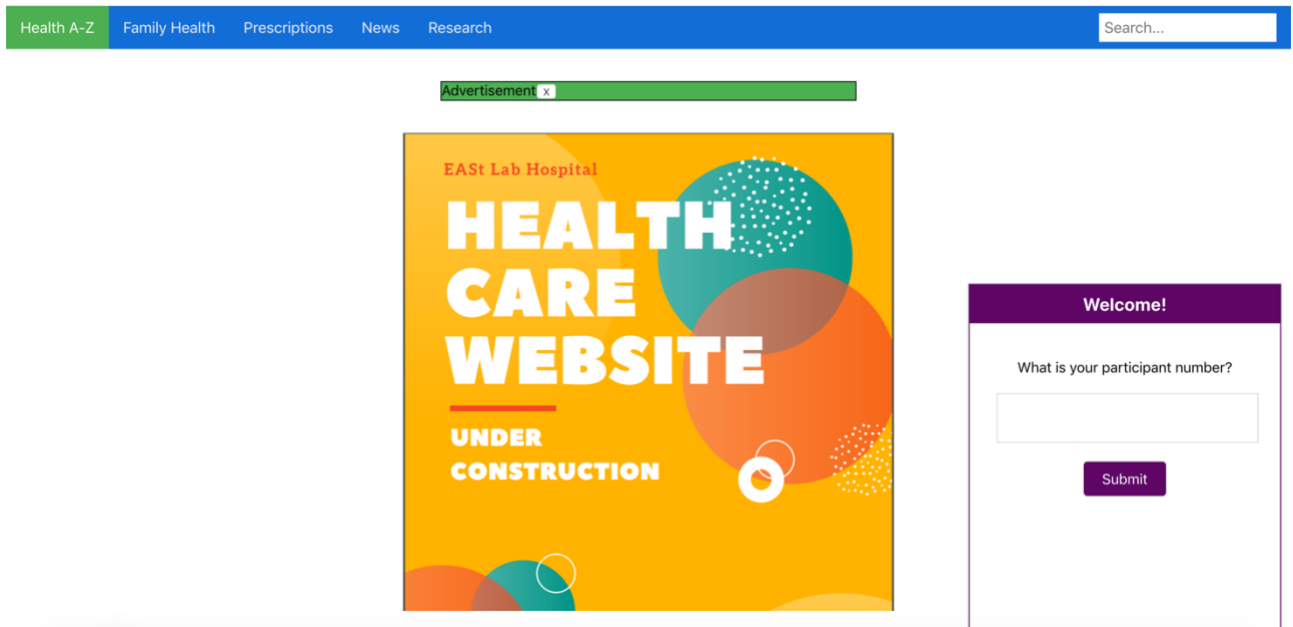
		Chatbot persona		
		Doctor	Nurse	Nursing Student
Language used by chatbot	Technical	12	12	12
	Non-technical	12	12	12

*Participants*

Participants (N=72) were between the ages of 18-26 years old and required to be able to read, write, and speak English. Participants were recruited from Clemson, SC. They received a compensation of \$10 for thirty minutes of their time at the end of the session. This design required 72 participants for power to be .8, medium effect size to be 0.5, and alpha to be 0.05.

**Apparatus and experimental setting**

This study used two computers (one Mac and one PC) and a health information website designed by the experimenter (see Figure 1). The website design was based on popular healthcare information sites such as WebMD and Mayo Clinic. The design attempted to replicate health websites as much as possible since the conditions of the study were examining healthcare website chatbots. The experiment was conducted in the Clemson EASt (Ergonomics & Applied Statistics) Lab with a typical table, chair, and computer set-up for the participant. A co-experimenter was sitting at a table in another room, separate from the participant, so as not to cause the participant to feel as though they were being closely watched and potentially induce Hawthorne’s effect.



**Figure 1: Healthcare website and chatbot used for experiment**

## **Procedure**

Participants were recruited through emails, flyers, and business cards. When they emailed the experimenter, the experimenter verified that the person was between the ages of 18-26 and could read, write, and speak English. If both requirements were confirmed, the experimenter scheduled the participant for a time slot. When the participant arrived, the experimenter greeted the participant and once again, verified the age of the participant and made note of the age in their participant numbered file. A co-experimenter then proceeded to give the IRB approved consent form (IRB2019-411) to the participant, instructed them to read over the information, and if everything was agreeable to the participant, obtained their written consent. All participants received a copy of this form at the end of their visit if they so desired. Once the participant completed the consent form, the co-experimenter began the experiment by directing the participant to fill out a demographic survey via Qualtrics on the computer. Once completed, the co-experimenter

assessed the participant's health literacy with the Short Assessment of Health Literacy – English (SAHL-E) (Lee, Stucky, Lee, Rozier, & Bender, 2010). The co-experimenter then directed the participant to take a paper pre-test on the health education subject of blood pressure. The co-experimenter presented the pre-test as a survey and told the participant to complete it to the best of their knowledge. After the pre-test finished, the co-experimenter went over the use of the website including general instructions for the participant. The co-experimenter instructed the participant to use the chatbot as part of the session and to not ignore it. They informed the participant that interacting with the chatbot was a good time to ask any questions they did not understand from the last survey (pre-test) or anything they wanted to learn about blood pressure. The co-experimenter also explained that the chatbot and website were in the “developmental stages” and so may take up to 30 seconds to respond. The co-experimenter had the participant type their participant number into the chatbot to sign in and again as the first text message in the chatbot. The typing of the number twice was explained to the participant as a way to start the chatbot. The second number typing was the indicator to the experimenter, who was controlling the chatbot responses, to send the welcome message. At this point, the health information seeking by the participant began. The co-experimenter closed the door of room where the participant was sitting. The experimenter, stationed in a separate room from the participant, ran the chatbot in a Wizard of Oz type of structure (e.g. they responded to the user with preconstructed answers). The participant had approximately 15 minutes to gather as much information as they needed to understand blood pressure. If they ran out of questions to ask before 15 minutes had passed, they were allowed to finish

early. Once they had gathered as much information as they wanted or 15 minutes went by, the participant took a paper post-test on blood pressure. The post-test was once again described as a survey to the participant and was the exact same as the pre-test. After the post-test, the participants moved back to the computer to take surveys through Qualtrics assessing the trustworthiness of the chatbot and the usability of the chatbot (Corritore et al., 2005; Lewis, 1995). After the surveys, the co-experimenter thanked the participant and handed them their copy of the informed consent if desired as well as gave them their \$10 gift card compensation.

### **Independent variables**

There were two independent variables (IV) for this study, one with a level of 2 and the other with a level of 3. The IV of level 2 was the language used by the chatbot, which was classified as technical and non-technical. The IV of level 3 was the persona of the chatbot which included doctor, nurse, and nursing student. Additional information like gender, age, and major was collected for demographic purposes.

### **Dependent variables**

The dependent variables were trust in the chatbot, effectiveness of the chatbot, and the usability of the chatbot. The effectiveness of the chatbot was assessed with a pre-post knowledge test. The trust of the chatbot and the usability of the chatbot were assessed with surveys (Corritore et al., 2005; Lewis, 1995).

### **Variable definitions**

For clarity, the following sections will explain some variable definitions included in this study to demonstrate how they were gathered and measured as well as any format

changes that occurred. Table 2 shows all possible variables and how they were measured or operationalized for a quick overview.

**Table 2: Variables and how they were measured for analysis**

<b>Variable</b>	<b>Operationalized</b>
Effectiveness	Posttest - Pretest scores
Trust	Trust survey
Usability	PSSUQ
Health literacy	SAHL-E evaluation
Number of I don't know response by chatbot	Count via transcript evaluation
Number of questions asked by participant	Count via transcript evaluation
Time taken with chatbot	Time log
Rate of questions per minute	Number of questions / time taken
Age	Demographic survey
Gender	Demographic survey
Education level	Demographic survey
Major	Demographic survey

The usability variable was measured with the Post-Study System Usability Questionnaire (PSSUQ). PSSUQ scores are calculated by averaging the 7-point Likert scales responses from all 16 questions. Normally, PSSUQ scores are displayed as strongly agree as 1 on the far left and strongly disagree as 7 on the far right. Through pilot testing, it was determined that having the scores displayed as strongly disagree on the left and strongly agree on the right was more consistent with other surveys used in the experiment (i.e. strongly agree became 7 and strongly disagree became 1). For analysis then, the scores were evaluated with high values indicating high usability and low values indicating low usability. The trust variable was measured using a web trust survey that



was transformed to a chatbot trust survey by replacing the word website with chatbot. An example is, “I trust this website,” turned into “I trust this chatbot.” The survey included a total of 15 questions. The effectiveness variable was calculated by the difference between the blood pressure pre and post-test. It was calculated by the number of questions correct on the post-test minus the number of questions correct on the pre-test.

### **Data analysis methodology**

#### *Aim 1 – Determining the effect of technical/non-technical language*

Aim 1 was focused on identifying the effect of technical and non-technical language on a healthcare chatbot’s effectiveness in helping a user understand information, on the trust the user places in the system, and on the usability of the chatbot. The potential need for non-technical language arises from health literacy issues that cause people and their caregivers to not understand healthcare discharge instructions (Vaigneur, 2015), to be embarrassed to ask follow up questions (Boren, 2009), and can result in increased costs of healthcare from readmissions and other associated costs of prolonged sickness (Manickam et al., 2019; National Network of Libraries of Medicine, 2019). Yet non-technical language usage may result in users not trusting the system or perceiving the system as providing incorrect or insufficient information (Haberstroh, 2010). For each session, there was a pre-test on the subject of blood pressure to see how much a participant knew on the subject as well as a post-test to see how much the participant learned. They did not know their score from the first test when taking the second test. Additionally, Qualtrics questionnaires on the trustworthiness and usability of the system were asked at the end of the session. Before determining the statistically significant

effect, the data was evaluated for normality and multicollinearity to determine the best generalized linear regression or logistic regression model to use for modeling the data as well as for any data transformation needs.

*Aim 2 – Determining the effect of the chatbot persona*

Aim 2 was focused on identifying the effect of chatbot persona on a healthcare chatbot's on the trust the user places in the system and on the usability of the chatbot. The chatbot persona was hypothesized to potentially affect the trust users put into the answers given by the chatbot as well as the overall experience of the chatbot. A chatbot with the doctor persona may be given more trust than a chatbot with the persona nursing student. The perceived usability of the chatbot was thought to change with the use of different titles as well. One study that looked at persona difference using a virtual agent found people responded differently and had different experiences based on the persona and characteristics of the agent (C. Wang et al., 2015). Surveys were in Qualtrics and were used to gather the trust and usability experience of the chatbot. These surveys were asked at the end of the 15-minute information seeking session. The results were evaluated using binary logistic regression models and linear regression models.

## CHAPTER THREE

### RESULTS

#### **Descriptive statistics**

The participant demographics in this study (N=74) are displayed in Table 1. Overall, the participant demographic included 40.5% males and 58.1% females. The participants were graduate students (41.9%) and undergraduate (48.1%) students with an average age of 21.86 years old and a standard deviation of 2.56 years. All of the participants were students as a result of the recruiting strategy and the availability of participants. Two participant's data were removed from the data analysis due to insufficient data in one case and a participant not engaging in the task (i.e., not asking blood pressure related questions) in the other case. Binary logistic regression and linear regression models were used in the statistical analysis. The analysis was performed via R Studio, version 1.1.463 (R Core Team, 2018).

**Table 3: Characteristics of study participants**

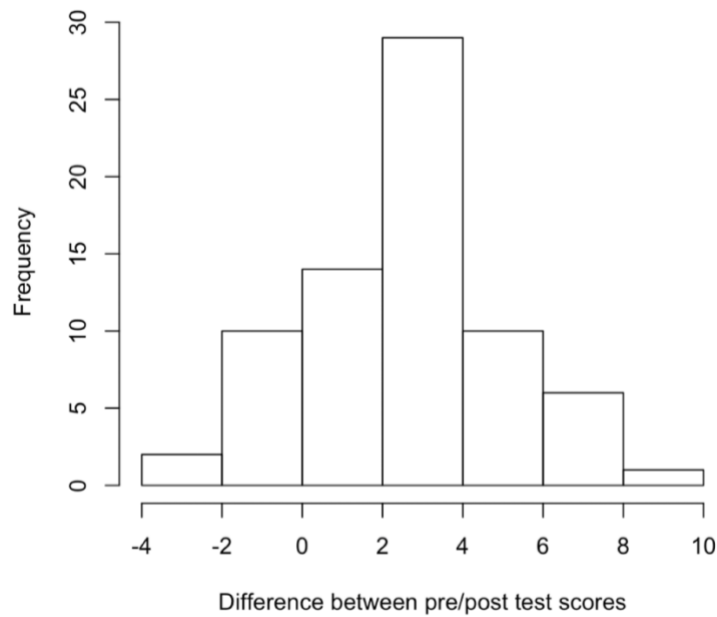
<b>Variable Name</b>	<b>N (%)</b>
Age	M=21.86, SD=2.56
Gender	
Male	30 (40.5)
Female	43 (58.1)
Prefer not to say	1 (1.4)
Race	
Caucasian	50 (67.6)
African American	9 (12.2)
Asian	15 (20.2)
Education, highest degree obtained	
High School/GED	39 (52.7)
Bachelors	21 (28.4)
Masters	11 (14.8)
Associate	3 (4.1)
Education, area of study	
STEM*	41 (55.4)
All other majors	33 (44.6)
Year in school	
Freshman	6 (8.1)
Sophomore	17 (23)
Junior	9 (12.2)
Senior	11 (14.8)
Graduate	31 (41.9)

Notes: \*STEM is defined as Science, Technology, Engineering and Math

### **Effectiveness**

To test the effectiveness of the chatbot, the participants were evaluated with a multiple-choice test before and after interacting with the chatbot (see Appendix A), resulting in pre/post test scores. The average improvement between the two tests was approximately 3 questions better ( $M=3.19$ ,  $SD = 2.46$ ) and the median value was an improvement of 4 questions. The difference between scores satisfied the normality assumption with a Shapiro-Wilk test  $p$ -value  $> 0.05$ . The Shapiro Wilk test assumes

normality and therefore a p-value of greater than 0.05 suggests that the data is not statistically different from a normal distribution. Additionally, the distribution had a relatively small skewness of -0.07. Distributions can be considered fairly symmetrical with skewness between -0.5 and 0.5 (Bulmer, 1979). The histogram of the effectiveness data (post-test-pretest scores) is shown in Figure 2.



**Figure 2: Histogram of effectiveness measure (i.e., difference between pre-post test scores)**

For the regression model, a median split was used to categorize the data into a binary variable of “high” and “low” values. This was done to identify what factors resulted in above median performance improvement and what factors lead to below median scores. Those who did 4 or better were the “high effectiveness” group and those who were below an improvement of 4 were the “low effectiveness” score group. An assumption for binary logistic regressions that needs to be met is little or no multicollinearity of the independent variables in the model (Iacobucci, Posavac, Kardes,

Schneider, & Popovich, 2015). The variance inflation factor (VIF) was used for the multicollinearity evaluation. The results indicated values of close to one for the predictors, suggesting that the independent factors are not correlated. If they were correlated, it could potentially cause inflation of significant values for the IVs. Once the assumption was met and data was split, the new binary variable resulted in an analysis using a binary logistic regression model.

Recall from Chapter 2, the independent experimental factors included in the study were the language used and chatbot persona. In addition to the experimental design variables, an interaction between persona and language, health literacy scores, and the number of “I don’t know” chatbot response were also included in the initial logistic regression model. All factors that were not significant in the model were removed except for the experimental factors which were left in all statistical models. A significant effect on effectiveness was found for the language factor ( $p < 0.05$ ), but persona was not a significant predictor. The summary of the finalized model is shown in Table 4. The model suggests that participants improved on their post-test (i.e., effectiveness) more when presented with technical language than when presented with non-technical language. The chatbot persona did not impact the improvement scores.

**Table 4: Binary logistic regression model for score difference of 4 or more**

Coefficients	Estimate	Std. Error	z value	p-value
Intercept	-0.34	0.48	-0.71	0.4776
Technical Language	1.05	0.49	2.12	0.0342 *
Nurse Persona	0.18	0.60	0.30	0.7637
Nursing Student Persona	-0.54	0.60	-0.89	0.3719

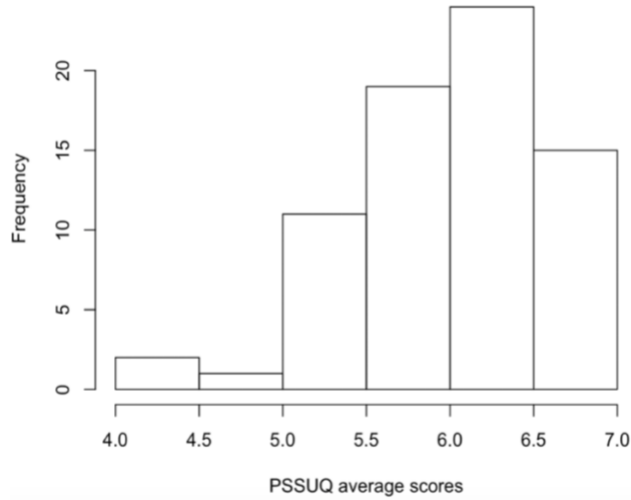
Note: \* indicates that the variable was statistically significant ( $P < 0.05$ )

## **Trust**

The trust metric was evaluated by assessing how participants rated their agreement with the statement, “I trust the chatbot” on a 7-point Likert scale (“strongly disagree” to “strongly agree”). The data was transformed into a binary variable of agree versus not agree with responses of “somewhat agree”, “agree”, and “strongly agree” identified as “agree” and all other responses categorized as not agree. This binary variable was then evaluated using a binary logistic regression model. The variance inflation factor (VIF) was calculated for the model. The results indicated values close to 1, demonstrating low or no multicollinearity of the predictors in the model. The predictors for the model included language and chatbot persona. Both predictors were found to be not significant. Other explanatory factors were included in initial models, but they were all insignificant. Overall, significant effects of the chatbot persona and language on participants’ trust were not found.

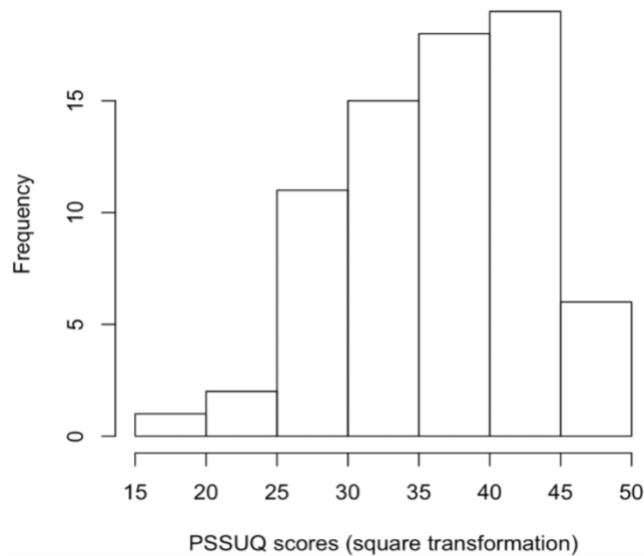
## **Usability**

The average for the usability scores was relatively high ( $M=6.01$ ,  $SD= 0.63$ ), indicating high perceived usability of the system. Usability was measured with a continuous variable (i.e. PSSUQ average scores) and as such the normality and skewness were evaluated. The normality and skewness for the average scores were not met (skewness =  $-0.6$ , Shapiro Wilks  $p$ -value =  $0.028$ ). The histogram of the data is shown in Figure 3.



**Figure 3: Histogram of average usability scores before transformation**

To reduce the skew, the averages were transformed using the square transformation of the values (skewness = -0.36, Shapiro Wilks p-value = 0.17) and the histogram of the transformed data is shown in Figure 5. Distributions can be considered fairly symmetrical with skewness between -0.5 and 0.5 (Bulmer, 1979).



**Figure 4: Histogram of average usability scores after transformation**



Once the data was transformed, a linear regression model was used. The variance inflation factor (VIF) was calculated for the model. The results had values of close to 1 for each predictor, suggesting low or no multicollinearity. The predictors for this model included language and chatbot persona. Health literacy was initially included but found to be not a significant predictor and was removed. Chatbot persona and language used were also found to not be significant predictors in the final model. Therefore, significant effects of the chatbot persona and language on usability were not found.

### **Qualitative transcript review**

A transcript review for qualitative metrics was also conducted to examine how, or in what manner, participants asked questions. While this was not a formal qualitative analysis, some insightful information was extracted that can support future research directions in this area. All 72 participants followed the general knowledge seeking task but the way in which they went about it varied. Thirty-five participant asked at least one question using singular 'I' form, typically regarding prevention for themselves (e.g., "How can I prevent high blood pressure from occurring?"). Twenty-five participants of the thirty-five asked more than 1 question in the 'I' form. Generally, the 'I' questions could be answered with generic responses but occasionally participants would ask things like "Am I at risk?" which based on the current chatbot pattern matching structure would not be able to answer explicitly for each person. When participants received an "I don't know" response from the chatbot, they generally reverted back to general knowledge seeking with questions like "What is blood pressure?" or "Who is affected most?". While the majority of the conversations were either general knowledge seeking or self-

concerned questions, one participant did ask about assisting other with the question, “How can I help someone with high blood pressure?”

Five participants used scenarios at some point in their dialogue (either at the beginning or in the middle after they had asked general questions) to see if they could be at risk or to understand which factors were included in the risk. The scenarios were generally self-centric as well in that the participants wanted to know if their scenario or life could affect blood pressure. Table 5 has some quotes from the transcripts that demonstrate these scenarios or concerns.

**Table 5: Scenario quotes from chatbot transcripts**

<b>Quotes</b>
“I am 25 year old [ <i>sic</i> ] and my mother and father both have high blood pressure. What are the odds that I get high blood pressure [ <i>sic</i> ]”
“what if I work out but eat unhealthy [ <i>sic</i> ]”
“For a young woman age [ <i>sic</i> ] 18, what is the likelihood of developing high blood pressure?”
“has [ <i>sic</i> ] stress in college aged kids started an increase in hypertension in younger people [ <i>sic</i> ]”

Additionally, the way in which participants interacted with Sarah (the chatbot) varied. When participants initially entered the chatbot, they received a welcome message from Sarah. Four participants out of 72 responded with a greeting or addressed Sarah personally (e.g. “Hello Nursing Student Sarah, what a strange name. I am Graduate Student (redacted),” “Hi Sarah!”). An additional person thanked Sarah at one point in their session (“Thanks for helping me nurse sarah”) while another two participants just said thanks at the very end of the session. At least two of the participants that addressed Sarah at the beginning also either addressed her again in the session or had generic conversation like comments (e.g. “Why are we not taught more about blood pressure

earlier in life?”, “You too, Nursing Student Sarah”). Still other participants said things like “Interesting,” “Okay,” and “That’s scary” when finding out information they did not know or by which they were fascinated.

Lastly, how people used grammar or shorthand in their conversation with the chatbot was evaluated. Most people asked their questions using question format such as “What is high blood pressure?” although even those varied quite greatly in terms of grammar. Some people used capitalization and questions marks while others just wrote the sentence with no capitalization and/or question mark. Other people preferred statements like “how to prevent blood pressure,” “symptoms of high blood pressure,” and even one as simple as “high blood pressure.” Two people used shorthand like “BP” presumably meant to indicate blood pressure. Overall, the way people formatted their questions grammatically and the way in which people expected to be able to input text and receive corresponding information varied widely.

## CHAPTER FOUR

### DISCUSSION

This thesis was an exploratory study investigating how the design of chatbots might impact trust, usability, and effectiveness in chatbot use for learning health information. Language was found to be significant in terms of the chatbot's effectiveness but had no impact with trust or usability. The results of the effectiveness regression model demonstrated that when technical language was used, participants improved more on their post-test scores than those who had nontechnical language. In the trust and usability models, language, in this study's manipulation, did not have a significant effect. Other predictors were included in some of the early effectiveness modeling, but all were removed due to not being significant. Some of these other predictors included health literacy, number of "I don't know" responses by the chatbot, time taken, and total number of participant questions. The only factor that was significant, and remained so, in all of the models was language.

The chatbot persona, evaluated in all the models, was found to not be a significant factor for effectiveness, trust, or usability based on the way it was implemented in this study. This is to say that the models suggest persona does not have an effect when the persona only consists of a name and introduction and is used for a general knowledge seeking task. The effects of persona may change when more visual features are added like a picture or if the knowledge seeking task became more personalized.

While there was no significant effect found in the models for usability and trust, even with other explanatory variables included, it interesting to compare these results to

previous studies that have found significance with similar factors. These other explanatory variables as well as language and persona are worth considering in future chatbot studies. In the trust model, it was shown that neither language nor persona had a significant effect on trust. This could be in part due to trust being difficult to measure and quantify (Hoffman, Johnson, Bradshaw, & Underbrink, 2013; Rogers et al., 2017). Trust is complex and dynamic with multiple factors contributing to an individual's trust (Endsley, 2017). The instruments used to capture trust are static surveys evaluated at the end of using a product or process. The instruments to measure trust may need to be more dynamic to capture the dynamic state of trust during a user's engagement with a system. Trust in automation is even more difficult to measure as people generally trust technology too much if they've been routinely exposed to it (Hoffman et al., 2013). There are also two phenomena known as negative trust and conditional trust that occur with technology (Hoffman et al., 2013). In negative trust, people expect automation to fail at some point and will therefore still trust the machine. Conditional trust refers to people trusting the technology to do certain things or tasks in certain contexts, such as searching for blood pressure information from a healthcare chatbot. Outside of that context or task though, trust can be quickly eroded. An example of the negative trust occurred when even the nine participants who received 5 or more responses of "I don't know" in regard to their questions still had relatively high trust ( $M=6.33$ ,  $SD=0.71$ ). This negative and conditional trust could have potentially contributed to the relatively high trust levels overall. Even health literacy was found to not significant in terms of trust. This finding is not consistent with health literacy literature which finds that people with higher health

literacy generally have higher trust (Diviani, van den Putte, Giani, & van Weert, 2015; Mackert, Mabry-Flynn, Champlin, Donovan, & Pounders, 2016). Future research should examine this effect of health literacy and trust in chatbots in more specificity.

The qualitative transcript review revealed interesting insights about how people use the internet to gather information and what they expect technology to be able to understand. The sentence structure varied greatly among participants. Some participants used full sentences and capitalization, others excluded capitalization or question marks, and still others used a sort of shorthand such as only typing “high blood pressure” as if they were performing a Google search. The shorthand use is particularly interesting because it resembles more of a general, all-encompassing search pattern rather than a directed question asking search pattern. Such generic searching demonstrates the need for chatbots to be able to process multiple kinds of search entries, whether it be formal input, shorthand, or all-encompassing search terms. When people used more “I” statement in their dialogue, the searching pattern became more directed with questions such as “Can I die from high blood pressure?” or “What can I do now to prevent it early?”. These questions also demonstrate the participants tendency to be self-concerned. Almost half of the participants, 35 out of 72, asked at least one form of a question using an I statement similar to the previous ones mentioned. The most common “I” question was some form of “How can I prevent it?” demonstrating people’s desire to not only understand a healthcare issue but also to learn how to avoid it. Additionally, it reveals a tendency for people to think in terms of themselves as individuals and their health. Only one person asked how they could help another person with high blood pressure.

Lastly, the review of interactions with the chatbot demonstrated that most people did not acknowledge Sarah, with only 4 out of 72 responding to the greeting, an additional 2 addressing Sarah at some other point in the dialogue, and a total of 4 participants thanking Sarah. Overall, the participants did not appear to engage with Sarah beyond its use as a chatbot to deliver information. This lack of interaction could be due to the persona not being salient or visually stimulating enough. Future research on how people perceive chatbots as information sources, how they want their information to be displayed, and how they want a chatbot to be presented needs to be further explored.

Chatbots are growing in use across the internet, not only for consumer products and website, but also within healthcare settings. Language was studied due to previous healthcare research on how patients understanding changes with language and structure (Vaigneur, 2015) as well as the cost of low health literacy on the healthcare system because of patients inability to understand their healthcare needs and directions (Bonet & Sasangohar, 2019; National Network of Libraries of Medicine, 2019). Persona was studied due to the effect of other virtual agents being more or less effective due to their perceived character (C. Wang et al., 2015). This study found the effect of language to be inconsistent with the previous research that suggested as language decreased, the easier it was for people to understand. The results associated with the persona conditions were not significant predictors in any of the assessments. This may be because the persona included only a name and title but did not have a picture or other visual stimulus and did not engage in any personalized dialog (e.g., asking the participant questions). Future research should continue research to support the development and revision of chatbot

design recommendations and guidelines, particularly for healthcare chatbots, to determine how people understand and use the information given to them.

### **Limitations**

There were several limitations associated with this study. Although the experimental setting attempted to replicate a healthcare website with a chatbot, the setting was actual a static website with a simulated chatbot. The responses were not truly determined by a computer but were instead accomplished with preconstructed responses resembling more of a messenger type system via a Wizard of Oz study. This replication may have impacted the results as the technology was simulated by the experimenter and not by the technology. Since the responses were given by a person, there is a possibility for variability in how the experimenter responded. Along with the experimenter's possible variability, there was variability in what questions participants asked and how participants asked those questions. While attempts were made before the experiment to acclimate the responder to possible types of questions and how to use general responses to different types of questions, this question/response variability may have impacted the results. Another limitation was the age of the participants for this study (i.e., 18-26 years-old). While this age range was selected to support a more homogeneous group of possible participants with experiences and knowledge associated with blood pressure, this does limit the generalizability of the study. Future work should more closely reflect the wider population ages, experiences, and health literacies in evaluating the usefulness of chatbots in healthcare applications.



## **Implications and future work**

Based on this study, the language that healthcare chatbots use can impact how well a user understands the information. This language phenomenon needs to be studied further. Since all the participants were college age students with relatively high health literacy it may be that technical language was more helpful to them. Technical language seemed to help participants understand the information better, at least for a general knowledge seeking task of understanding blood pressure. Future research should look at how technical and nontechnical language perform in low and high health literacy populations. Future research should also evaluate how information presented changes when performing a general knowledge seeking task versus more personal information seeking. As participants look for health recommendations in different contexts, environments and using different devices and technology, chatbots need to be able to adapt to personal needs. Understanding how those personal needs change the language or presentation of the chatbot is crucial.

In this exploratory study, personas (as implemented) did not appear to be important for effectiveness, trust, or usability of the healthcare chatbot. Future studies should examine other ways of representing personas to evaluate if the specific implementation of the personas in this study, or if personas in general are not as useful in this context. Other representations could include visual stimulus added like pictures or caricatures. As the representations transform into 3D or virtual agents, the required characteristics need to change too and follow other design patterns (Radziwill & Benton, 2017; C. Wang et al., 2015).

Lastly, health literacy and its impacts on chatbot language, trust, and usability needs to be further studied. In this initial study, it was found that health literacy, as a possible explanatory variable, did not have an impact on the trust or usability in the chatbot which is inconsistent with previous research (Diviani et al., 2015; Mackert et al., 2016). Future research should examine health literacy as a factor as well as use qualitative measures such as interview to investigate why relationships, or lack of relationships, are transpiring.

## **Conclusion**

With increased internet usage in everyday life, ways in which people obtain healthcare information is changing. It is important to continue to develop proper healthcare websites with information that can be personalized for users based on factors that matter such as age, gender, and health literacy (Beery, 1995; Boren, 2009; National Network of Libraries of Medicine, 2019). Personalized healthcare information that is understood by each patient and caregiver will allow people to maintain ownership of their health-care decisions and have confidence in their decisions. Additionally, as patients are better able to understand their healthcare needs, they can make decisions that allow for quicker recovery, create less impact on the healthcare system, and ultimately lower overall costs for the patient and the healthcare system.

Healthcare chatbots and telehealth medicine are also on the rise, not only in the last decade, but particularly as a response to the 2020 Covid-19 situation. People had to find other ways to receive their routine care, because they were told to stay home, and doctors cancelled all but essential visits. One technology implementation that saw an

increase was telehealth medicine where doctors and patients communicated virtually via videos, emails, and chats. There is possibility for chatbots to help for these particular cases (Kimball, 2020). Healthcare chatbots could allow patients to ask simple questions instead of calling the doctor or before calling the doctor to prepare. If patients could also type in a list of symptoms, the chatbot could assist in letting them know if they do not have something like Covid-19 where people did not know the symptoms and were very concerned about them. Therefore, the design of these chatbots is crucial to understand and implement correctly to not cause more confusion or panic. Findings of this study demonstrated promise of significant effects of language on effectiveness. Continued study will determine if significant effects are found in other scenarios, different representations of persona, and when people transition to looking for personal health information. Since the goals of users for different chatbots may be different depending on the domain, design recommendations should also be studied for each domain to minimize risk of undervaluing or overvaluing an aspect of a chatbot.

## APPENDICES

## Appendix A

### Pre/Post test on blood pressure

Choose the best option.

Participant # \_\_\_\_\_

1. Blood pressure has two parts, the systolic and diastolic pressure. What does the systolic blood pressure represent?
  - a. It represents the pressure in the arteries when the heart rests between beats.
  - b. It is a representation of the total volume of blood in your circulatory system.
  - c. It represents the pressure of blood through your arteries when the heart is contracting.
  - d. It is the number of times the left and right atria contracts within a minute.
2. Which of these blood pressure readings is the most ideal?
  - a. Around 80/110
  - b. Between 40/80
  - c. Higher than 130/90
  - d. Lower than 120/80
3. Which factor below is the number one cause of high blood pressure?
  - a. Aging
  - b. Stress
  - c. Unknown
  - d. Obesity
4. If you are suffering from high blood pressure, you may have:
  - a. Back pain
  - b. Higher risk of heart attack and stroke
  - c. Numb, tingling feeling in left arm
  - d. Diarrhea
5. Medication for high blood pressure is usually taken:
  - a. On a lifelong basis
  - b. Only under stressful situations
  - c. When doing physically demanding activities
  - d. When a person has decreased energy levels
6. Which of these is more likely to increase your blood pressure long term?
  - a. Physical activity
  - b. High cholesterol level
  - c. Ice cream
  - d. Salt or sodium intake
7. Which of these can be harmful to people who are suffering from high blood pressure?
  - a. Over the counter cold and flu medicines
  - b. Eggs
  - c. Physical activity
  - d. Microwaves
  - e. Omega-3

8. Blood pressure has two parts, the systolic and diastolic pressure. What does the diastolic blood pressure indicate?
  - a. It represents the pressure in the arteries when the heart rests between beats.
  - b. It is a representation of the total volume of blood in your circulatory system.
  - c. It represents the pressure of blood through your arteries when the heart is contracting.
  - d. It is the number of times the left and right atria contracts within a minute.
9. What is the top number of the blood pressure reading?
  - a. Systolic
  - b. Diastolic
  - c. Tricyclic
  - d. Probiotic
10. What is the bottom number of the blood pressure reading?
  - a. Systolic
  - b. Probiotic
  - c. Diastolic
  - d. Tricyclic
11. What is another term for high blood pressure?
  - a. Laziness
  - b. Hypertension
  - c. Hyperlipidemia
  - d. Hypotension
12. What is the most common risk associated with low blood pressure?
  - a. Dizziness or fainting
  - b. Hair loss
  - c. Flushed face
  - d. Skin rash
13. For a young, healthy individual, what is the best way to prevent high blood pressure?
  - a. Nothing because it's genetic
  - b. Exercise regularly
  - c. Intake more sodium
  - d. It is only possible with medication
14. What percentage of women aged 35-44 will have high blood pressure?
  - a. 20%
  - b. 33%
  - c. 40%
  - d. 25%
15. What ethnic group is most at risk for developing high blood pressure?
  - a. Hispanic
  - b. Asian and Pacific Islanders
  - c. African American
  - d. Caucasian
16. Over a lifetime, what is the risk of developing high blood pressure?

- a. 20%
- b. 90%
- c. 50%
- d. 75%

## Appendix B

### Trust Survey (from Qualtrics)

Q1 <p>The chatbot provides truthful information.</p>

- Strongly agree
  - Agree
  - Somewhat agree
  - Neither agree nor disagree
  - Somewhat disagree
  - Disagree
  - Strongly disagree
- 

Q2 <p>The information provided by the chatbot is believable.</p>

- Strongly agree
  - Agree
  - Somewhat agree
  - Neither agree nor disagree
  - Somewhat disagree
  - Disagree
  - Strongly disagree
-



Q3 <p>The content of the chatbot reflects competency.</p>

- Strongly agree
  - Agree
  - Somewhat agree
  - Neither agree nor disagree
  - Somewhat disagree
  - Disagree
  - Strongly disagree
- 

Q4 <p>The chatbot content reflects expertise.</p>

- Strongly agree
  - Agree
  - Somewhat agree
  - Neither agree nor disagree
  - Somewhat disagree
  - Disagree
  - Strongly disagree
-

Q1 <p>The chatbot provides truthful information.</p>

- Strongly agree
- Agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Disagree
- Strongly disagree

End of Block: Honesty

---

Start of Block: Predictability

Q5 <p>The chatbot content is what I expected.</p>

- Strongly agree
  - Agree
  - Somewhat agree
  - Neither agree nor disagree
  - Somewhat disagree
  - Disagree
  - Strongly disagree
-

Q6 <p>There were no surprises in how the chatbot responded to my actions.</p>

- Strongly agree
  - Agree
  - Somewhat agree
  - Neither agree nor disagree
  - Somewhat disagree
  - Disagree
  - Strongly disagree
- 

Q7 <p>The chatbot content is predictable.</p>

- Strongly agree
- Agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Disagree
- Strongly disagree

End of Block: Predictability

---

Start of Block: Perceived ease of use

Q8 <p>Learning to operate this chatbot was easy for me.</p>

- Strongly agree
  - Agree
  - Somewhat agree
  - Neither agree nor disagree
  - Somewhat disagree
  - Disagree
  - Strongly disagree
- 

Q9 <p>I found it easy to get this chatbot to do what I wanted it to do.</p>

- Strongly agree
  - Agree
  - Somewhat agree
  - Neither agree nor disagree
  - Somewhat disagree
  - Disagree
  - Strongly disagree
-

Q10 <p>I found the chatbot easy to use.</p>

- Strongly agree
- Agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Disagree
- Strongly disagree

End of Block: Perceived ease of use

---

Start of Block: Risk

Q11 <p>I am taking a chance interacting with this website.</p>

- Strongly agree
  - Agree
  - Somewhat agree
  - Neither agree nor disagree
  - Somewhat disagree
  - Disagree
  - Strongly disagree
-

Q12 <p>I feel I must be cautious when using this website.</p>

- Strongly agree
  - Agree
  - Somewhat agree
  - Neither agree nor disagree
  - Somewhat disagree
  - Disagree
  - Strongly disagree
- 

Q13 <p>It is risky to interact with this chatbot.</p>

- Strongly agree
- Agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Disagree
- Strongly disagree

End of Block: Risk

---

Start of Block: Trust

Q14 <p>I believe this chatbot is trustworthy.</p>

- Strongly agree
  - Agree
  - Somewhat agree
  - Neither agree nor disagree
  - Somewhat disagree
  - Disagree
  - Strongly disagree
- 

Q15 <p>I trust this chatbot.</p>

- Strongly agree
- Agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Disagree
- Strongly disagree

## Appendix C

### Usability (PSSUQ) survey

The Post-Study Usability Questionnaire		Strongly Agree				Strongly Disagree				
		1	2	3	4	5	6	7		NA
1	Overall I am satisfied with how easy it is to use this system.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>
2	It was simple to use this system	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
3	I was able to complete the tasks and scenarios quickly using this system.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
4	I felt comfortable using this system.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
5	It was easy to learn to use this system.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
6	I believe I could become productive quickly using this system.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
7	The system gave error messages that clearly told me how to fix problems.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
8	Whenever I made a mistake using the system, I could recover easily and quickly.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
9	The information (such as online help, on-screen messages and other documentation) provided with system was clear.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
10	It was easy for me to find the information I needed.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
11	The information was effective in helping me complete the tasks and scenarios.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
12	The organization of information on the system screens was clear.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
13	The interface* of this system was pleasant.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
14	I liked using the interface of this system.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
15	This system has all the functions and capabilities I expect it to have.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		
16	Overall, I am satisfied with this system.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		

The "interface" includes those items that you use to interact with the system. For example, some components of the interface are the keyboard, the mouse, the microphone, and the screens (including their graphics and language).



## Appendix D

### Technical chatbot answers

Hello, my name is Nurse Sarah. I'm here to help you learn about blood pressure today. You can ask questions about understanding blood pressure, learning how to manage or prevent it, who is affected, and more. What is your first question?

#### **Generic**

One moment please.

Are you asking about systolic and diastolic?

I am sorry, I am unable to answer that question. I am only trained to answer questions related to blood pressure topics. Do you have questions regarding blood pressure?

I am sorry, I am unable to answer that question. Do you have another question about blood pressure?

I am sorry but it does not appear that I have an answer for that. I will look into that in the future. Do you have another question about blood pressure?

I am only a chatbot and I don't know quite know what you are asking. Can you please ask your question in a different way?

I am only a chatbot and I don't know how to answer your question. Can you please ask your question in a different way?

Do you have any more questions?

Okay. Thank you and have a great day!

#### **Where can I find more information about high blood pressure?**

The American Heart Association has more information on blood pressure if you wish to explore more later. I cannot currently send you there.

#### **Risk**

**Why should I care?** (<https://www.webmd.com/hypertension-high-blood-pressure/5-misconceptions-about-hypertension>; <https://www.sentara.com/healthwellness/data/blogs/5-reasons-it-is-important-to-manage-your-high-blood-pressure.aspx>, Kaplan, N. M., & Lieberman, E. (1979); Galton, L. (1973); Wade, C. (1975))

Hypertension is the largest single causative factor in all deaths. Hypertension (high blood pressure) causes the arterioles to tighten, resulting in the heart having to work harder to pump

blood through the tissues to extremities and vital organs at a normal rate. Hypertension is a dangerous ailment because of its effect on the walls of arteries. Hypertension accelerates the ailment of atherosclerosis which causes the arteries to harden and reduces the elasticity of the affected arteries. Over time, this hardening can have detrimental effects including increased risk of brain hemorrhage, myocardial infarction, coronary artery disease, and kidney failure.

### What are the risk factors?

(<https://www.sentara.com/healthwellness/data/blogs/5-reasons-it-is-important-to-manage-your-high-blood-pressure.aspx>, Kaplan, N. M., & Lieberman, E. (1979); Galton, L. (1973); Wade, C. (1975))

Hypertension (high blood pressure) is a dangerous ailment because of its effect on the walls of arteries. It accelerates the ailment of atherosclerosis which causes the arteries to harden and reduces the elasticity of the affected arteries. Over time, this hardening can have detrimental effects including, but not limited to, increased risk of brain hemorrhage, myocardial infarction, coronary artery disease (3x more likely), and kidney complications. Coronary artery disease and brain hemorrhage are the first and fifth leading cause of death in the United States.

### What are comorbidities with high blood pressure?

(Kaplan, N. M., & Lieberman, E. (1979))

Some possible factors that may be observed simultaneously or in conjunction with high blood pressure include high cholesterol, obesity, or diabetes. Increased incidences of the following diseases have been found when hypertension (high blood pressure) is present: uterine fibromyomas, gout, quadriplegia, menopause, and polycythemia (slow growing blood cancer). Research is still needed to learn about these diseases and their connection to high blood pressure.

### Symptoms

#### What are symptoms? What are symptoms of high blood pressure?

(Wade, C. (1975); Childre, D. L., & Wilson, B. (2006); Galton, L. (1973); Kaplan, N. M., & Lieberman, E. (1979))

Hypertension (high blood pressure) is particularly dangerous as it is generally symptomless. Individuals can have it for years without knowing. One in three Americans with the condition are not consciously aware of having developed it and this absence of symptoms gives it its name: the “silent” killer. Many of the possible symptoms of hypertension (e.g., headaches, vertigo, light-headedness, nosebleeds) are just as commonly in people with normal blood pressure. Symptoms simply cannot be relied upon as early warning signs of hypertension.

#### How can you tell if you have high blood pressure? How do I know if I have high blood pressure?

(Wade, C. (1975))

The best way to determine if an individual has hypertension (high blood pressure) is through regular checkups. Many of the symptoms of hypertension (e.g., headaches, vertigo, light-headedness, nosebleeds) are just as commonly in people with normal blood pressure. Symptoms simply cannot be relied upon as early warning signs of hypertension.

## **Causes**

### **What affects blood pressure? What causes high blood pressure?**

(<https://www.webmd.com/hypertension-high-blood-pressure/guide/blood-pressure-causes#1>, Galton, L. (1973); Childre, D. L., & Wilson, B. (2006))

The specific cause of hypertension is unknown, but several factors may play a role including age, race, family history, weight, tobacco consumption, being physically inactive, stress, sodium, alcohol, and certain chronic conditions.

**Age:** The risk of high blood pressure increases as an individual ages with an approximately 90% chance of developing high blood pressure in a lifetime. The stress an individual incurs in life results in higher blood pressure levels along with the loss in elasticity of the arteries due to an increased age.

**Race:** Hypertension (high blood pressure) is particularly common among people of African heritage, often developing at an earlier age than it does in Caucasians. Serious complications, such as brain hemorrhage, myocardial infarction, and kidney failure, are also more common in people of African heritage potentially due to this increase prevalence of hypertension although the exact reason for the racial disparity remains unclear.

**Family history:** Hypertension (high blood pressure) can be genetic; it tends to run in families particularly as a comorbidity of other hereditary diseases that may have hypertension as a complication such as diabetes.

**Being overweight or obese:** The more an individual weighs the more blood carrying oxygen and nutrients to their tissues they need to supply via the arteries. As the volume of blood circulated through the arteries increases, so does the pressure on the artery walls resulting in damage to the arteries. The heart also has to work harder to pump more blood through a larger body causing an increased risk for hypertension (high blood pressure) as well as coronary heart disease and myocardial infarction.

**Not being physically active:** People who are inactive tend to have higher heart rates, creating strain on the heart to contract and relax more frequently. The higher a heart rate is, the harder the heart must work with each contraction resulting in a stronger force on the arteries; this strong force causes the slow

deterioration of the arteries walls and their elasticity. Lack of physical activity also increases the risk of being overweight if not managed with a proper diet.

It is also important to understand that blood pressure may increase temporarily initially after exercising but in the long-term, being active can help lower blood pressure levels as well as potentially help lose weight which is also important for managing blood pressure. Before starting any workout regime though, you should consult your doctor to ensure that it is safe to do so.

Using tobacco: Not only does smoking or chewing tobacco immediately raise blood pressure temporarily, but the chemicals in tobacco can damage the lining of the arterial walls. This can cause arteries to narrow and increases the risk of coronary artery disease; secondhand smoke also can increase the risk of coronary artery disease. Coronary artery disease is the leading cause of death in the US.

Too much sodium (salt) in your diet: Too much sodium consumption narrows the passageways of small arteries by causing arterioles to swell and therefore results in exerting more force on the arterial walls. Too much sodium in a diet also causes the body to retain fluid which results in more volume of blood and further raises blood pressure which in turn strains the heart.

Too little potassium in your diet: Potassium helps balance the amount of sodium in your cells (sodium causes the artery passageways to narrow putting more pressure on the artery walls and more fluid to be retained which denotes a larger volume of blood in the body's system which further raises blood pressure). If you don't get enough potassium in your diet or retain enough potassium, you may accumulate too much sodium in your blood.

Drinking too much alcohol: By drinking alcohol only in moderation, generally one drink a day for women or two a day for men, you can potentially lower your blood pressure by about 4 mm Hg. Over time though, heavy drinking can damage your heart, possibly resulting in hypertension (high blood pressure) development, as well as consuming more than moderate amounts of alcohol can raise blood pressure by several points. For references, one drink equals 12 ounces of beer, five ounces of wine or 1.5 ounces of 80-proof liquor.

Stress: Chronic stress or even just stressful moments may contribute to hypertension (high blood pressure) by creating temporary high levels of stress which can lead to a temporary increase in blood pressure. Over the long-term, these increases in blood pressure damage the arterial walls and can result in hypertension. Also, when an individual feels or perceives stress, the body releases the hormone cortisol which constricts artery passageways and interacts with the kidney to retain fluids, both of which can increase blood pressure. Stress can also

cause people to try to relax by eating more, using tobacco, or drinking alcohol, all of which can increase problems with high blood pressure.

Certain chronic conditions: Certain chronic conditions, such as kidney disease, diabetes, chronic stress, and sleep apnea, may increase your risk of high blood pressure. Some conditions may be inherited and as such may require different approaches for managing potential risk of developing hypertension (high blood pressure). If you believe a chronic condition to be the case for your situation, consult your doctor.

## **Facts**

### **How many people suffer from high blood pressure?**

([https://www.cdc.gov/bloodpressure/about.htm?CDC\\_AA\\_refVal=https%3A%2F%2Fwww.cdc.gov%2Fbloodpressure%2Ffaq.htm](https://www.cdc.gov/bloodpressure/about.htm?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fbloodpressure%2Ffaq.htm))

Approximately 1 in 3 American adults have high blood pressure resulting in around 75 million American adults being affected.

### **What ethnic group is most likely to experience high blood pressure?**

(<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4108512/>, Kaplan, N. M., & Lieberman, E. (1979); Galton, L. (1973); Childre, D. L., & Wilson, B. (2006))

African Americans have an increased prevalence of hypertension (high blood pressure) and higher complications rates. The reasons for the racial disparities in elevated blood pressure and hypertension-related risk outcomes remain unclear.

### **How likely is it for someone to have high blood pressure? Chances of developing high blood pressure? How many people develop high blood pressure in their lifetime?**

(<https://www.ncbi.nlm.nih.gov/books/NBK9636/>)

Hypertension (high blood pressure) generally progresses throughout an individual's lifetime. It eventually affects nearly everyone with an approximately 90% chance of developing it in a lifetime.

### **Are there over the counter medicines for treating high blood pressure?**

(<https://www.heart.org/en/health-topics/high-blood-pressure/changes-you-can-make-to-manage-high-blood-pressure/understanding-overthecounter-otc-medications-and-high-blood-pressure>)

There are no over-the-counter medicines or drinks that can substitute for prescription medications and lifestyle modifications when it comes to treating high blood pressure. Before taking any over-the-counter medicine, drug, or supplement that claims to lower blood pressure, talk to a healthcare provider or physician. The over-the-counter medications may not work as advertised and/or interfere with other prescribed medications; in fact, some can even raise blood pressure.

**Does over the counter medicine effect blood pressure?** (<https://www.heart.org/en/health-topics/high-blood-pressure/changes-you-can-make-to-manage-high-blood-pressure/understanding-overthecounter-otc-medications-and-high-blood-pressure>)

Always read the labels on all over-the-counter medications, especially if you have hypertension (high blood pressure). If you have hypertension or high blood pressure, and especially if you are on prescription medication, consult your healthcare professional before taking any over-the-counter medications or supplements. The use of decongestants may raise blood pressure or interfere with prescribed blood pressure medications.

**Will Omega-3 affect my blood pressure?**  
(<https://www.verywellhealth.com/fish-oil-for-better-blood-pressure-89331>)

Some research actually suggests that omega-3 fish oil supplements may help control blood pressure levels. Something that may affect blood pressure is over-the-counter medicine, particularly decongestants as they can raise blood pressure or interfere with prescribed blood pressure medications. Decongestants should be taken with caution if an individual has hypertension (high blood pressure).

## **Prevention**

**How do I find my own blood pressure?**  
([medicalnewstoday.com/articles/321429.php#checking-pressure-manually](https://www.medicalnewstoday.com/articles/321429.php#checking-pressure-manually); Childre, D. L., & Wilson, B. (2006); Wade, C. (1975))

Blood pressure is typically measured using a sphygmomanometer and stethoscope. Using these instruments, a person can measure the contraction of the heart muscle that ejects blood during systole period, creating an increase in pressure in the arteries (known as the systolic pressure). The system also measures the pressure in the arteries during a relaxed state, known as the diastole period, right before the heart contracts (known as the diastolic pressure). The numbers from the two readings combined will generate a blood pressure reading, written as the systolic reading above the diastolic reading.

**How often do you want to get your blood pressure measured?**  
(<https://www.webmd.com/hypertension-high-blood-pressure/qa/how-often-should-i-get-my-blood-pressure-checked>)

The recommended number of blood pressure measurements changes based on an individual's age, health conditions, and other factors than can potentially influence blood pressure. Normally, blood pressure should be measured each time you visit the doctor's office. For a specific number of blood pressure readings, please observe the general guidelines:

On average, if your blood pressure is less than 120/80 mm Hg (considered normal blood pressure), get it measured at least every 2 years or more frequently as your doctor suggests. If your blood pressure is borderline high (called prehypertension) -- systolic blood pressure between 120 mm Hg and 139 mm Hg or diastolic blood pressure of 80 mm Hg to 89 mm Hg -- check it at least every year or more often at your doctor's recommendation. If your reading is 140/90 mm Hg or higher, you have high blood pressure and need to see your doctor. You may need to start medication or make lifestyle changes.

### **Is there a cure for high blood pressure?**

(<https://www.heart.org/en/health-topics/high-blood-pressure/changes-you-can-make-to-manage-high-blood-pressure>)

While there is no cure, using medications as prescribed and making lifestyle changes can enhance your quality of life, reduce blood pressure levels, and reduce your risk of coronary artery disease, brain hemorrhage, and kidney disease.

### **What are ways to manage high blood pressure? What should I do if I am not safe? What are the treatment options for high blood pressure?**

(<https://www.mayoclinic.org/diseases-conditions/high-blood-pressure/in-depth/high-blood-pressure/art-20046974>; Galton, L. (1973); Childre, D. L., & Wilson, B. (2006))

In order to manage hypertension (high blood pressure), there are a few lifestyle changes that can be made to address the disease and its complications. If you currently are diagnosed with hypertension and the lifestyle changes do not work for you, you may have to take medication on a lifelong basis to manage your high blood pressure. Consult your doctor either way before implementing any changes to ensure that the issue you have is high blood pressure and not another diagnosis.

To manage or prevent high blood pressure over the long term from accruing, it is suggested to exercise regularly, lose weight, eat a healthy diet with fewer saturated fats and cholesterol, consume less sodium, quit smoking (if applicable), limit alcohol and caffeine, and reduce stress. In serious cases, it may be required to take medication.

### **What can I do to prevent? What can I do to avoid getting high blood pressure?**

(<https://www.mayoclinic.org/diseases-conditions/high-blood-pressure/in-depth/high-blood-pressure/art-20046974>, Galton, L. (1973); Childre, D. L., & Wilson, B. (2006))

In order to prevent hypertension (high blood pressure), there are a few lifestyle changes that can be made to address the disease and its complications. The recommendations for preventing hypertension are similar for how to manage hypertension if you already have it. Consult your doctor either way before implementing any changes.

To manage or prevent high blood pressure over the long term from accruing, it is suggested to exercise regularly, lose weight, eat a healthy diet with fewer saturated fats

and cholesterol, consume less sodium, quit smoking (if applicable), limit alcohol and caffeine, and reduce stress. In serious cases, it may be required to take medication.

**Lose weight:** Blood pressure often increases as weight increases resulting in hypertension (high blood pressure) because the more an individual weighs the more blood that is needed to be pumped to carry oxygen and nutrients to the tissues via the arteries. As the volume of blood circulated through arteries increases, so does the pressure on your arterial walls resulting in damage to the arteries. Being overweight also can cause sleep apnea, which further raises blood pressure. Weight loss is one of the most effective lifestyle changes for controlling hypertension.

**Exercise regularly:** Regular physical activity — such as 150 minutes a week, or about 30 minutes most days of the week — can lower blood pressure by about 5 to 8 mm Hg if an individual has high blood pressure. It's important to be consistent because if a person stop exercising, their blood pressure can rise again. If an individual has elevated blood pressure, exercise can help avoid developing hypertension (high blood pressure). If someone already have hypertension, regular physical activity can bring blood pressure down to safer levels.

It is also important to know that your blood pressure may increase initially after exercising but in the long-term being active can help lower blood pressure levels as well as potentially help to lose weight which is also important for managing high blood pressure. Before starting any workout regime, you should consult your doctor to ensure that it is safe to do so.

### **What kind of exercise is good with high blood pressure?**

(Childre, D. L., & Wilson, B. (2006))

Exercise such as aerobic exercise is the generally the best exercise for individuals who have hypertension (high blood pressure) as well as for lowering blood pressure in general; examples of this type of exercise include walking, swimming and biking. Isometric exercise, like heavy weightlifting, is generally not recommended. Lighter weights with more repetition should be fine and can possibly even help with flexibility. Consult your doctor or physician for exercise recommendations.

**Eat healthy:** Eating a diet that is rich in whole grains, fruits, vegetables and low-fat dairy products and skimps on saturated fat and cholesterol can lower blood pressure by up to 11 mm Hg if an individual has high blood pressure.

### **What foods should I avoid if I have high blood pressure?**

**Consume less sodium:** Even a small reduction in the sodium in a diet can improve heart health and reduce blood pressure by about 5 to 6 mm Hg if an individual has



high blood pressure. The effect of sodium intake on blood pressure varies among groups of people. In general, limit sodium to 2,300 milligrams (mg) a day or less; however, a lower sodium intake — 1,500 mg a day or less — is ideal for most adults. Too much salt consumption narrows the passageways of small arteries and increasing the force exerted on the arterial walls. Salt can also cause the body to retain fluid which results in more volume of blood and further raises blood pressure.

**Limit amount of alcohol:** By drinking alcohol only in moderation, generally one drink a day for women or two a day for men, you can potentially lower your blood pressure by about 4 mm Hg. One drink equals 12 ounces of beer, five ounces of wine or 1.5 ounces of 80-proof liquor. Consuming more than moderate amounts of alcohol can actually raise blood pressure by several points and heavy drinking can even damage the heart.

**Quit smoking and/or tobacco use:** Each cigarette an individual smokes increases their blood pressure immediately after they finish for many minutes. Not only does smoking or chewing tobacco immediately raise blood pressure, but the chemicals in tobacco can damage the lining of the artery walls; this can cause arteries to narrow and increases the risk of coronary artery disease. Additionally, secondhand smoke can increase the risk of coronary artery disease which is the leading cause of death in the US. Stopping the use of tobacco products or smoking can help blood pressure return to normal range.

**Cut back on caffeine:** The role caffeine plays in blood pressure is still debated. Caffeine can raise blood pressure up to 10 mm Hg in people who rarely consume it, but people who drink coffee regularly may experience little or no effect on their blood pressure. Although the long-term effects of caffeine on blood pressure aren't clear, it's possible blood pressure may slightly increase.

**Reduce stress:** Chronic stress or even just stressful moments may contribute to hypertension (high blood pressure) by creating temporary high levels of stress which can lead to a temporary increase in blood pressure. Over the long-term, these increases in blood pressure damage the artery walls and can result in hypertension. Some suggested ways to reduce stress include taking more breaks during the day, practicing meditation, or attending a yoga class. Occasional stress also can contribute to high blood pressure if an individual reacts to stress by eating unhealthy food, drinking alcohol or smoking.

### **What things besides diet and exercises affect blood pressure?**

(<https://www.mayoclinic.org/diseases-conditions/high-blood-pressure/in-depth/high-blood-pressure/art-20046974>)

Some factors that may reduce blood pressure, besides regular exercise and eating a healthy balanced diet, include consume less sodium, quit smoking (if applicable), limit alcohol and caffeine, and reduce stress.

### Are eggs healthy for me to take if I had blood pressure problems?

(Wade, C. (1975))

Eating a diet that is rich in whole grains, fruits, vegetables and low-fat dairy products and skimps on saturated fat and cholesterol can lower blood pressure by up to 11 mm Hg if an individual has had high blood pressure. Additionally, losing weight can help manage high blood pressure levels and one possible way to lose weight would be to add protein, including eggs, chicken, and fish, into a diet. Protein can help a person ideally feel full throughout the day and help them reduce their total amount of food consumption. The biggest food concern with hypertension and high blood pressure is food rich in sodium and fat.

### Understanding

#### What is blood pressure?

(Wade, C. (1975); Childre, D. L., & Wilson, B. (2006); Galton, L. (1973); Kaplan, N. M., & Lieberman, E. (1979))

Blood pressure is a component of the circulatory system and is the amount of pressure exerted on the blood as it passes through the arteries. When the left ventricle of the heart contracts it forces the blood out into the arteries; the muscular linings of the arteries resist the pressure and blood vessels are squeezed out into smaller vessels of the body. Blood pressure is the collective amount of pressure the blood is under as a result of the pumping heart, resistance of arterial walls, and the closing of the heart valves. Overall, this pressure is maintained by the contraction and relaxation of the arteries and the pumping of the heart (the contraction is the systolic pressure and the relaxation is the diastolic pressure).

#### What is a healthy blood pressure?

(Wade, C. (1975); Childre, D. L., & Wilson, B. (2006); Galton, L. (1973); Kaplan, N. M., & Lieberman, E. (1979))

Blood pressure numbers of less than 120/80 mm Hg are considered normal for the majority of people. Since no two people are exactly alike, including potential force of heartbeat and activity of arterioles, there is some range to what can be considered normal for healthy individuals.

#### Can blood pressure vary?

(Wade, C. (1975); Childre, D. L., & Wilson, B. (2006); Galton, L. (1973); Kaplan, N. M., & Lieberman, E. (1979))

Blood pressure varies, quite normally, at different times for individuals (i.e., it can increase temporarily during physical activity or decrease during sleep).

### Is the recommended blood pressure appropriate for everybody?

(<https://www.heart.org/en/health-topics/high-blood-pressure/understanding-blood-pressure-readings>)

The ideal blood pressure is generally consistent for everyone with a normal reading containing values lower than 120/80 mm Hg (read as '120 over 80'). There have been discrepancies in the recent health literature regarding the normal ranges for individuals in different age groups. It has been suggested that the ideal blood pressure values are different for older individuals. (As people age, the stress they may incur in their life may be a reason to suggest lower blood pressure levels).

## High Blood Pressure

### What is a high blood pressure?

(<https://ihealthlabs.com/Bloodpressure>, (Wade, C. (1975); Childre, D. L., & Wilson, B. (2006); Galton, L. (1973); Kaplan, N. M., & Lieberman, E. (1979))

There are four general stages of high blood pressure that include elevated blood pressure, hypertension stage 1, hypertension stage 2, and hypertension crisis. The most common type of high blood pressure diagnosis is known as essential or idiopathic hypertension, consists of these aforementioned stages, and affects 90-95% of the people who are diagnosed with high blood pressure.

### Elevated

Elevated blood pressure is when readings consistently range from 120-129 systolic and less than 80 mm Hg diastolic. People with elevated blood pressure are likely to develop high blood pressure unless steps are taken to control the condition.

### Hypertension Stage 1

Hypertension Stage 1 is when blood pressure consistently ranges from 130-139 systolic or 80-89 mm Hg diastolic. At this stage of high blood pressure, doctors are likely to prescribe lifestyle changes and may consider adding blood pressure medication based on your risk of atherosclerotic cardiovascular diseases (ASCVD), myocardial infarction or brain hemorrhage.

### Hypertension Stage 2

Hypertension Stage 2 is when blood pressure consistently ranges from 140/90 mm Hg or higher. At this stage of hypertension, doctors are likely to prescribe a combination of blood pressure medications and lifestyle changes to decrease the risk of complications like brain hemorrhage, myocardial infarction, coronary artery disease, and kidney failure.

### Hypertensive crisis

This stage of hypertension requires medical attention. If your blood pressure readings suddenly exceed 180/120 mm Hg, wait five minutes and then test your blood pressure again to see if it is not a temporary increase. If your readings are still unusually high or if you are also experiencing signs of possible organs damage such as chest pain, shortness of breath, numbness, change in vision or difficulty speaking, call 911 immediately. You could be experiencing a hypertensive crisis.

### Is high blood pressure worse than low pressure?

(<https://www.cheatsheet.com/health-fitness/which-is-more-dangerous-high-blood-pressure-or-low-blood-pressure.html/>)

Generally, hypertension (high blood pressure) is more concerning than hypotension (low blood pressure) as its symptoms and complications can cause lasting damage to the body via brain hemorrhage, myocardial infarction, coronary artery disease, or kidney failure. This may not always be the case as hypotension can cause dizziness and fainting which could result in serious injury. Conditions are very dependent on the situation and the individual, especially considering factors such as age, gender, race, family history, etc.

### When do men start to see an increase in blood pressure? Are men more likely to have high blood pressure than women?

([https://www.heart.org/idc/groups/heart-public/@wcm/@sop/@smd/documents/downloadable/ucm\\_319587.pdf](https://www.heart.org/idc/groups/heart-public/@wcm/@sop/@smd/documents/downloadable/ucm_319587.pdf))

Hypertension and higher blood pressure levels begin to rise around the age of 40 for most people (men and women) although it is possible to experience high blood pressure when individuals are younger or if they have a chronic condition like diabetes or sleep apnea. Until about age 64, high blood pressure is observed more commonly in men. This switches around 65 when high blood pressure becomes more prevalent in women.

### When do women start to see an increase in blood pressure?

([https://www.heart.org/idc/groups/heart-public/@wcm/@sop/@smd/documents/downloadable/ucm\\_319587.pdf](https://www.heart.org/idc/groups/heart-public/@wcm/@sop/@smd/documents/downloadable/ucm_319587.pdf))

Hypertension and higher blood pressure levels begin to rise around the age of 40 for most people (men and women) although it is possible to experience high blood pressure when individuals are younger or if they have a chronic condition like diabetes or sleep apnea.

Until about age 64, high blood pressure is observed more often in men. This switches around 65 when high blood pressure is then more common in women with African American women aged 65 having the highest incidence rate of high blood pressure.

**How many women/men between the ages of 35-44 have high blood pressure? Can young people have high blood pressure?**

([https://www.heart.org/idc/groups/heart-public/@wcm/@sop/@smd/documents/downloadable/ucm\\_319587.pdf](https://www.heart.org/idc/groups/heart-public/@wcm/@sop/@smd/documents/downloadable/ucm_319587.pdf))

Hypertension and higher blood pressure levels begin to rise around the age of 40 for most people (men and women) although it is possible to experience high blood pressure when individuals are younger or if they have a chronic condition like diabetes or sleep apnea.

Approximately 20% of women between the ages of 35-44 will have developed high blood pressure. Approximately 25% of men between the ages of 35-44 will have developed high blood pressure.

**What is high blood pressure called?**

(Wade, C. (1975); Childre, D. L., & Wilson, B. (2006); Galton, L. (1973); Kaplan, N. M., & Lieberman, E. (1979))

From a medical perspective, high blood pressure is termed hypertension, or sometimes essential hypertension, while low blood pressure is termed hypotension.

Low Blood Pressure

**Is there such a thing as low blood pressure? What is low blood pressure? Is it possible to have low blood pressure (i.e., hypotension)? If so, what would be considered a low blood pressure reading?**

(<https://www.webmd.com/heart/understanding-low-blood-pressure-basics#1>)

Hypotension (low blood pressure) is a blood pressure reading of less than 90/60. Severely low blood pressure can be a sign of an underlying problem -- especially in the elderly -- where it may cause inadequate blood flow and deprive the body of enough oxygen to carry out its normal functions resulting in damage to the heart, brain, and other vital organs.

**What is bad about low blood pressure?**

(<https://www.webmd.com/heart/understanding-low-blood-pressure-basics#1>,  
<https://www.healthline.com/health/hypotension#types>)

In healthy individuals, hypotension (low blood pressure) without any symptoms is not usually a concern and does not need to be treated. Hypotension with symptoms can be a concern as it can cause dizziness, weakness, fainting and a risk of injury from falls. Severely low blood pressure can be a sign of an underlying problem -- especially in the elderly -- where it may cause inadequate blood flow and deprive the body of enough oxygen

to carry out its normal functions resulting in damage to the heart, brain, and other vital organs.

### What are symptoms of low blood pressure?

(<https://www.heart.org/en/health-topics/high-blood-pressure/the-facts-about-high-blood-pressure/low-blood-pressure-when-blood-pressure-is-too-low>; Childre, D. L., & Wilson, B. (2006))

Hypotension (low blood pressure) can include symptoms such as lightheadedness, vertigo, fainting (syncope), blurred vision, fatigue, or lack of concentration. Severely low blood pressure may cause inadequate blood flow and deprive the body of enough oxygen to carry out its normal functions resulting in damage to the heart, brain, and other vital organs. These complications and problems are especially concerning for elderly individuals.

## Systolic/Diastolic

### What are the two types of blood pressure?

### What number is high/low? What is the difference between systolic and diastolic?

### What does the top/bottom number mean? What do the two numbers mean?

(Wade, C. (1975); Childre, D. L., & Wilson, B. (2006); Galton, L. (1973); Kaplan, N. M., & Lieberman, E. (1979))

Systolic is the top number and it represents the maximum pressure in your arteries as your heart contracts to pump blood to the body from the left ventricle of your heart. Diastolic is the bottom number and it represents the minimum pressure of blood in the arteries, or maximum relaxation, where the heart is relaxing between beats before pumping more blood into the system.

### What is more important — the Systolic or Diastolic reading?

(Galton, L. (1973))

Both readings are important; the systolic reading measures an individual's blood pressure during a heart contraction and the diastolic reading measures blood pressure between heart contractions (or when it is resting). The two readings combined, with systolic on top and diastolic on bottom, are used to produce a blood pressure reading, and if either one or both are higher than the normal range, they can indicate potential issues and complications.

### Are they independent?

(Wade, C. (1975); Childre, D. L., & Wilson, B. (2006); Galton, L. (1973); Kaplan, N. M., & Lieberman, E. (1979))

Systolic and diastolic readings are not independent as they indicate opposite functions of the heart contracting and relaxing and the pressure in the arteries during these functions. Systolic is the top number and it represents the maximum pressure in your arteries as

your heart contracts to pump blood to the body from the left ventricle of your heart. Diastolic is the bottom number and it represents the minimum pressure of blood in the arteries, or maximum relaxation, where the heart is relaxing between beats before pumping more blood into the system.

### What is systolic blood pressure?

(Wade, C. (1975); Childre, D. L., & Wilson, B. (2006); Galton, L. (1973); Kaplan, N. M., & Lieberman, E. (1979))

Systolic is the top number and it represents the maximum pressure in your arteries as your heart contracts to pump blood to the body from the left ventricle of your heart.

### What is diastolic blood pressure?

(Wade, C. (1975); Childre, D. L., & Wilson, B. (2006); Galton, L. (1973); Kaplan, N. M., & Lieberman, E. (1979))

Diastolic is the bottom number and it represents the minimum pressure of blood in the arteries, or maximum relaxation, where the heart is relaxing between beats before pumping more blood into the system.

### Answers from:

#### Books

Wade, C. (1975). *Fact/book on hypertension (high blood pressure) and your diet*. New Canaan, CT: Keats Pub.

Childre, D. L., & Wilson, B. (2006). *The HeartMath approach to managing hypertension: the proven, natural way to lower your blood pressure*. Oakland, CA: New Harbinger.

Galton, L. (1973). *Silent disease: hypertension*. New York, NY: Crown Publishers, Inc.

Kaplan, N. M., & Lieberman, E. (1979). *Clinical hypertension*. Baltimore, MD: The Williams & Wilkins Company.

#### Websites

<https://ihealthlabs.com/Bloodpressure>

<https://www.heart.org/en/health-topics/high-blood-pressure/understanding-blood-pressure-readings>

<https://www.webmd.com/hypertension-high-blood-pressure/guide/blood-pressure-causes#1>

<https://www.mayoclinic.org/diseases-conditions/high-blood-pressure/in-depth/high-blood-pressure/art-20046974>

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4108512/>

## Appendix E

### Nontechnical chatbot answers

Hello, my name is Nurse Sarah. I'm here to help you learn about blood pressure today. You can ask questions about understanding blood pressure, learning how to manage or prevent high blood pressure, who is affected, and more. What is your first question?

#### **Generic**

One moment please.

Are you asking about systolic and diastolic?

I am sorry, I am unable to answer that question. I am only trained to answer questions related to blood pressure topics. Do you have questions regarding blood pressure?

I am sorry, I am unable to answer that question. Do you have another question about blood pressure?

I am sorry but it does not appear that I have an answer for that. I will look into that in the future. Do you have another question about blood pressure?

I am only a chatbot and I don't know quite know what you are asking. Can you please ask your question in a different way?

I am only a chatbot and I don't know how to answer your question. Can you please ask your question in a different way?

Do you have any more questions?

Okay. Thank you and have a great day!

#### **Where can I find more information about high blood pressure?**

The American Heart Association has more information on blood pressure if you wish to explore more later. I cannot currently send you there.

#### **Risk**

##### **Why should I care?**

(<https://www.webmd.com/hypertension-high-blood-pressure/5-misconceptions-about-hypertension>; <https://www.sentara.com/healthwellness/data/blogs/5-reasons-it-is-important-to-manage-your-high-blood-pressure.aspx>, Kaplan, N. M., & Lieberman, E. (1979); Galton, L. (1973); Wade, C. (1975))



High blood pressure is the largest single causative factor in all deaths. High blood pressure can lead to damage of your blood vessels, heart, kidneys, and other organs in your body. This results in the heart having to work harder to pump blood at a normal rate. Also, high blood pressure is a dangerous concern because of its effect on the walls of arteries. It increases atherosclerosis which causes the arteries to harden and reduces their flexibility. Over time, this hardening can have harmful effects. The effects include increased risk of stroke, heart attack, heart disease, and kidney failure.

### What are the risk factors?

(<https://www.sentara.com/healthwellness/data/blogs/5-reasons-it-is-important-to-manage-your-high-blood-pressure.aspx>, Kaplan, N. M., & Lieberman, E. (1979); Galton, L. (1973); Wade, C. (1975))

High blood pressure is a dangerous concern because of its effects on the arteries. It increases atherosclerosis which causes the arteries to harden and reduces their flexibility. Over time, this hardening can have harmful effects. The effects include increased risk of stroke, heart attack, heart disease (3 times more likely), and kidney failure. Heart disease is the leading cause of death in the US. Stroke is the fifth leading cause.

### What are comorbidities with high blood pressure?

(Kaplan, N. M., & Lieberman, E. (1979))

When a person has high cholesterol, diabetes, or is overweight, they may also have high blood pressure. There are times too when a person with high blood pressure is later seen with other conditions. These conditions include growths in the uterus, gout, quadriplegia, menopause and a type of slow growing blood cancer. Research is still needed to learn about these connections.

## Symptoms

### What are symptoms? What are symptoms of high blood pressure?

(Wade, C. (1975); Childre, D. L., & Wilson, B. (2006); Galton, L. (1973); Kaplan, N. M., & Lieberman, E. (1979))

High blood pressure is particularly dangerous as it does not have distinct symptoms. Many of the symptoms of high blood pressure (e.g., headaches, dizziness, fatigue, nosebleeds) are just as common in people with normal blood pressure. People can have high blood pressure for years without knowing. One in three Americans with the condition are not aware of having it. This absence of symptoms gives it its name: the “silent” killer. Symptoms simply cannot be trusted as early warning signs of high blood pressure.

### How can you tell if you have high blood pressure? How do I know if I have high blood pressure?

(Wade, C. (1975))

The best way to know if blood pressure is high is through regular doctor checkups. Many of the symptoms of high blood pressure (e.g., headaches, dizziness, fatigue, nosebleeds) are just as common in people with normal blood pressure. Symptoms simply cannot be trusted as early warning signs of high blood pressure.

## Causes

### What affects blood pressure? What causes high blood pressure?

(<https://www.webmd.com/hypertension-high-blood-pressure/guide/blood-pressure-causes#1>, Galton, L. (1973); Childre, D. L., & Wilson, B. (2006))

The exact cause of high blood pressure is unknown. Several factors may play a role. These factors include age, race, family history, and weight. A few other possible factors include tobacco use, being physically inactive, stress, salt intake, alcohol use as well as some chronic illnesses.

**Age:** The risk of high blood pressure increases as a person ages. The stress a person experiences in life may result in higher blood pressure levels. Age also decreases the flexibility of the arteries. This is a problem as blood pressure is an interaction between the arteries and the heart.

**Race:** High blood pressure is more common in people of African descent. It often develops at an earlier age than it does in whites. Serious problems such as stroke, heart attack and kidney failure are also more common for African Americans. The reason for these additional problems could be due to the increase risk of high blood pressure. The reason for the racial gap for increased risk of blood pressure and related issues is still unclear.

**Family history:** High blood pressure can be genetic. In other words, it is passed down from parents or grandparents to kid. It tends to be in families who also have other hereditary diseases that include high blood pressure. One example of such a possible genetic disease is diabetes.

**Being overweight or obese:** The more a person weighs the more blood they need to move through their body. Blood carries oxygen and other nutrient to tissues and important organs. As the volume of blood moving through the body and arteries increases so does the pressure on the arterial walls. This pressure on the walls causes damage. Being overweight also means the heart has to work harder to pump the increased blood amount through the larger body. This also increases the risk for high blood pressure as well as for heart disease and heart attacks.

**Not being physically active:** People who are not active usually have higher heart rates. These higher heart rates create strain on the heart to contract and relax more frequently. The higher a heart rate is, the harder the heart must work with each contraction. This causes a stronger force to be applied to the arteries. This greater

force leads to damage in the arterial walls and a decrease in artery flexibility. Lack of physical activity also increases the risk of being overweight if not properly managed with diet.

On a side note, it is important to know that blood pressure can increase temporarily right after a workout. In long-term health, working out helps lower blood pressure. It can also help to lose weight which is important for low blood pressure levels. Before starting any workout program, you should consult your doctor to make sure that it is safe to do so.

Using tobacco: Smoking and chewing tobacco will immediately raise blood pressure temporarily. Over the long term, the chemicals in tobacco can damage the arterial walls. It also causes arteries to narrow or constrict. This increases the risk for heart disease. Also, secondhand smoke can also increase the risk of heart disease. Heart disease is the leading cause of death in the US.

Too much salt in your diet: Too much salt intake can narrow small arteries by causing arterioles to swell. This results in more pressure being applied to the artery walls. This is part of what causes high blood pressure. Also, too much salt in a diet causes the body to retain fluids. Keeping fluids means there is a greater volume of blood in the body. This larger volume of blood further raises blood pressure and puts strain on the heart.

Too little potassium in your diet: Potassium helps balance the amount of salt in your cells. Salt cause the arteries to narrow and fluid to be keep in the body. If you do not get enough potassium in your diet or retain enough potassium, you may store too much salt in your blood.

Drinking too much alcohol: Drinking more than the moderate amounts of alcohol can raise blood pressure by a several points. Over time, heavy drinking can damage the heart. On the other hand, drinking alcohol in moderation can actually lower blood pressure by a few points. Generally, one drink a day for women and two a day for men is the suggested amount. One drink is 12 ounces of beer, five ounces of wine, or 1.5 ounces of liquor.

Stress: Chronic stress and even temporary stress can contribution to high blood pressure. Temporary high levels of stress can lead to a temporary increase in blood pressure. Over the long-term, this increase in blood pressure damages arterial walls. Also, when a person feels stressed, the body releases a hormone known as cortisol. Cortisol constricts artery passageways and interacts with the kidney to keep fluid. Both of these problems can increase blood pressure. Stress can also cause people to try to relax by eating more, using tobacco, or drinking alcohol. All of these can also increase problems with high blood pressure.

Certain chronic conditions: Some chronic conditions may increase the risk of high blood pressure. These conditions include kidney disease, diabetes, chronic stress, and sleep apnea. Some of the conditions may be genetic. Therefore, managing high blood pressure may need different methods depending on how a person develops it. If you believe you have high blood pressure from a chronic condition, talk to your doctor.

## **Facts**

### **How many people suffer from high blood pressure?**

([https://www.cdc.gov/bloodpressure/about.htm?CDC\\_AA\\_refVal=https%3A%2F%2Fwww.cdc.gov%2Fbloodpressure%2Ffaq.htm](https://www.cdc.gov/bloodpressure/about.htm?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fbloodpressure%2Ffaq.htm))

Around 1 out of 3 American adults have high blood pressure. This is about 75 million affected adults.

### **What ethnic group is most likely to experience high blood pressure?**

(<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4108512/>, Kaplan, N. M., & Lieberman, E. (1979); Galton, L. (1973); Childre, D. L., & Wilson, B. (2006))

The ethnic group most likely to have high blood pressure is African Americans. They have an increased risk of having high blood pressure and having complications (like heart attacks or strokes). The reasons for the racial difference of high blood pressure and related issues are unclear.

### **How likely is it for someone to have high blood pressure? Chances of developing high blood pressure? How many people develop high blood pressure in their lifetime?**

(<https://www.ncbi.nlm.nih.gov/books/NBK9636/>)

High blood pressure generally develops in a lifetime. In fact, people have about a 90% chance of developing high blood pressure in their life.

### **Are there over the counter medicines for treating high blood pressure?**

(<https://www.heart.org/en/health-topics/high-blood-pressure/changes-you-can-make-to-manage-high-blood-pressure/understanding-overthecounter-otc-medications-and-high-blood-pressure>)

In terms of handling high blood pressure, there are no over-the-counter (OTC) drugs that can replace medications and lifestyle changes. Before taking any OTC medicine that says it lowers blood pressure, talk to a doctor. The OTC pills may not work as it states. They may actually interfere with other pills. In fact, some OTC pills can even raise blood pressure.

### **Does over the counter medicine effect blood pressure?** (<https://www.heart.org/en/health-topics/high-blood-pressure/changes-you-can-make-to-manage-high-blood-pressure/understanding-overthecounter-otc-medications-and-high-blood-pressure>)

Always read the labels on all over-the-counter (OTC) medicines, especially if you have high blood pressure. If you have high blood pressure, and are on a prescribed pill, consult your doctor before taking any OTC drugs. The use of decongestants in OTC pills may raise blood pressure. They can also interfere with prescribed blood pressure medications.

### Will Omega-3 affect my blood pressure?

(<https://www.verywellhealth.com/fish-oil-for-better-blood-pressure-89331>)

There is some dispute on omega-3's effect on blood pressure. Some research believes that it may help control blood pressure. Other research has not found a correlation.

Something that may affect blood pressure is over-the-counter (OTC) medicine. OTC drugs may actually raise blood pressure. This is particularly true for decongestants. Decongestants can even interfere with prescribed blood pressure medications. If a person has high blood pressure, OTC medicine should be taken with caution.

### Prevention

#### How do I find my own blood pressure?

([medicalnewstoday.com/articles/321429.php#checking-pressure-manually](http://medicalnewstoday.com/articles/321429.php#checking-pressure-manually); Childre, D. L., & Wilson, B. (2006); Wade, C. (1975))

Blood pressure is usually measured with a pressure cuff and stethoscope. Using these two tools, a person can measure the systolic and diastolic pressure. Systolic represents the maximum pressure in the blood vessels as the heart contracts. Diastolic represents the minimum pressure of blood in the arteries. This is when the heart is relaxing between beats. The numbers from these two readings create the blood pressure reading. The numbers are read as the systolic on the top and the diastolic on the bottom.

#### How often do you want to get your blood pressure measured?

(<https://www.webmd.com/hypertension-high-blood-pressure/qa/how-often-should-i-get-my-blood-pressure-checked>)

The recommended number of blood pressure measurements may depend on a few factors. These factors include age, health conditions, and other potential blood pressure causes. Normally, blood pressure should be checked when you visit the doctor. The following general guidelines can give an idea for how often to check if you are still unsure:

On average, for a normal blood pressure you should check it at least every 2 years. This may be more frequently if your doctor recommends it. Normal blood pressure values are less than 120/80 mm Hg. If blood pressure is borderline high (called prehypertensive), you should check it at least every year. This can be more often at your doctor's recommendations. Borderline high values are between 120 mm Hg and 139 mm Hg over 80 mm Hg to 89 mm Hg. If blood pressure is 140/90 mm Hg or higher, you have high

blood pressure and should see a doctor. You may need to start medication or lifestyle changes.

### Is there a cure for high blood pressure?

(<https://www.heart.org/en/health-topics/high-blood-pressure/changes-you-can-make-to-manage-high-blood-pressure>)

There is no “cure” for high blood pressure. Using medications as prescribed and making lifestyle changes can help. These changes can improve quality of life, reduce blood pressure levels, and reduce the risk of heart disease, stroke, and kidney disease.

### What are ways to manage high blood pressure? What should I do if I am not safe? What are the treatment options for high blood pressure?

(<https://www.mayoclinic.org/diseases-conditions/high-blood-pressure/in-depth/high-blood-pressure/art-20046974>, Galton, L. (1973); Childre, D. L., & Wilson, B. (2006))

To manage high blood pressure, there are some lifestyle changes that can be made. These changes help reduce the chances of getting high blood pressure. Reducing high blood pressure can also reduce its other possible health problems (like heart attack or stroke). If you already have high blood pressure and lifestyle changes do not work, you may have to take medication. This medication is taken on a lifelong basis. Talk to your doctor either way before implementing any changes.

To manage or prevent high blood pressure, it is recommended to exercise regularly, lose weight, eat a healthy diet, use less salt, quit smoking (if relevant), limit alcohol and caffeine use, and reduce stress. In serious cases, it may be required to take medication. These methods should help stop blood pressure from rising and are good practices for other health benefits.

### What can I do to prevent? What can I do to avoid getting high blood pressure?

(<https://www.mayoclinic.org/diseases-conditions/high-blood-pressure/in-depth/high-blood-pressure/art-20046974>, Galton, L. (1973); Childre, D. L., & Wilson, B. (2006))

To prevent high blood pressure, there are some lifestyle changes that can be made. These changes help reduce the chances of getting high blood pressure. Reducing high blood pressure can also reduce its other possible health problems (like heart attack or stroke). The ways to prevent high blood pressure are also very common for managing it if a person already has it. Talk to your doctor either way before implementing any changes.

To manage or prevent high blood pressure, it is recommended to work out regularly, lose weight, eat a healthy diet, eat less salt, quit smoking (if relevant), limit alcohol and caffeine use, and reduce stress. In serious cases, it may be required to take medication. These methods should help stop blood pressure from rising and are good practices for other health benefits.

**Lose weight:** Blood pressure often increases as weight increases. Increased weight causes blood pressure to rise because more blood is needed to be pumped through a larger body. The pressure on the arterial walls increases as the volume of blood in the arteries increases. This results in damage to the arteries. Being overweight can also create sleep apnea. Sleep apnea is a condition that increases blood pressure. Losing weight is one of the best lifestyle changes for controlling blood pressure levels.

**Exercise regularly:** Regular physical activity can help lower blood pressure. Regular exercise is about 150 minutes a week or five days a week with 30-minute exercises. It is important to be regular with working out. Blood pressure can rise again if a person stops. If a person has elevated blood pressure, working out can help prevent them from developing high blood pressure. If a person already has high blood pressure, working out can bring blood pressure down to safer levels.

It is important to note, blood pressure can increase briefly right after a workout. In the long-term, working out can lower blood pressure levels as well as overall weight. Before starting any working program, you should talk to your doctor to make sure it is safe to do so.

**What kind of exercise is good with high blood pressure?**

(Childre, D. L., & Wilson, B. (2006))

Aerobic exercise is the best exercise for people who have high blood pressure. It can also help lower blood pressure in general. Examples of aerobic exercise include walking, swimming, and biking. Isometric exercise is usually not the best. This type of exercise includes heavy lifting. Lighter weights with more repetition should be fine. That may even help with flexibility. Consult your doctor for work out recommendations.

**Eat healthy:** Eating a healthy diet can lower blood pressure. A healthy diet for blood pressure includes a lot of whole grains, fruits, vegetables, and low-fat dairy products. This diet has little saturated fats and cholesterol. This is usually if a person already has high blood pressure. It can help people though to eat healthier in general and prevent them from developing high blood pressure.

**What foods should I avoid if I have high blood pressure?**

**Eat less salt:** Eating less salt can reduce blood pressure and improve heart health. The effect of salt intake on blood pressure changes between groups of people. Try to limit intake to about 2300 mg a day or less. As a person ages, a lower salt intake of around 1500 mg a day is even better. Too much salt can narrow the arteries and has the body retain fluids. Both of these can result in increasing blood pressure.

Limit amount of alcohol: Drinking alcohol in moderation can potentially lower blood pressure. Generally, one drink a day for women and two a day for men is suggested amount. One drink is 12 ounces of beer, five ounces of wine, or 1.5 ounces of liquor. Drinking more than the moderate amounts of alcohol can raise blood pressure levels. Heavy drinking can even damage the heart.

Quit smoking and/or tobacco use: Smoking increases blood pressure right after a person finishes. The chemicals in the tobacco can also damage the lining of the artery walls. This can cause arteries to narrow. Smoking, as well as secondhand smoking, can increase the risk of heart disease. Heart disease is the leading cause of death in the US. Blood pressure can return to normal levels if a person stops smoking or using tobacco products.

Cut back on caffeine: The effects of caffeine on blood pressure are still discussed. Caffeine can raise blood pressure a small amount in people who rarely consume it. For people who drink coffee regularly, they may experience little or no effect on their blood pressure. As for the long-term effects of caffeine on blood pressure, that is still unknown. It is possible blood pressure may slightly increase over time with caffeine use.

Reduce stress: Chronic stress or even just stressful events may lead to high blood pressure. Temporarily high levels of stress can cause temporary increases in blood pressure. These increases in blood pressure can damage the arterial walls. This damage can cause high blood pressure. Some recommended ways to reduce stress include taking more breaks, meditating, or attending a yoga class. Occasional stress can also lead to high blood pressure if a person reacts to stress by eating unhealthy foods, drinking alcohol, or smoking.

### What things besides diet and exercises affect blood pressure?

(<https://www.mayoclinic.org/diseases-conditions/high-blood-pressure/in-depth/high-blood-pressure/art-20046974>)

Eating healthy food and working out can reduce blood pressure levels. Other factors that may reduce blood pressure include:

- eat less salt
- quit smoking
- limit alcohol
- limit coffee and soda
- reduce stress

### Are eggs healthy for me to take if I had blood pressure problems?

(Wade, C. (1975))



Eating a healthy diet can lower blood pressure. A healthy diet for blood pressure includes a lot of whole grains, fruits, vegetables, and low-fat dairy products. This diet has little saturated fats and cholesterol. Also, losing weight can help manage high blood pressure. One possible way to lose weight would be to add protein into a diet. Some possible proteins to add are eggs, chicken, and fish. Protein can help a person feel full throughout the day. Ideally, they could help a person reduce their total amount of food intake. The biggest food concern with high blood pressure is food rich in salt and fat.

## **Understanding**

### **What is blood pressure?**

(Wade, C. (1975); Childre, D. L., & Wilson, B. (2006); Galton, L. (1973); Kaplan, N. M., & Lieberman, E. (1979))

Blood pressure is a way of measuring how much force is being applied to the walls of your blood vessels (artery) as blood flows through them. It is a part of the circulatory system in your body. When the heart contracts, it pushes the blood into the arteries. The arteries resist the pressure. Blood is then squeezed into smaller vessels of the body. Therefore, blood pressure is the combined amount of pressure in the blood, resistance of the arterial wall, and the closing of the heart valve. Overall, blood pressure is maintained by the contraction and relaxation of the blood vessels (contraction is the systolic pressure and relaxation is the diastolic pressure).

### **What is a healthy blood pressure?**

(Wade, C. (1975); Childre, D. L., & Wilson, B. (2006); Galton, L. (1973); Kaplan, N. M., & Lieberman, E. (1979))

Normal blood pressure is a reading with values less than 120/80 mm Hg. This is generally the same for most people. Since no two people are exactly alike, there is some range for what could be considered normal for healthy individuals.

### **Can blood pressure vary?**

(Wade, C. (1975); Childre, D. L., & Wilson, B. (2006); Galton, L. (1973); Kaplan, N. M., & Lieberman, E. (1979))

It is important to know blood pressure varies at different times throughout the day. This is quite normal. It can increase briefly during physical activity or decrease during sleep.

### **Is the recommended blood pressure appropriate for everybody?**

(<https://www.heart.org/en/health-topics/high-blood-pressure/understanding-blood-pressure-readings>)

Good blood pressure levels are mostly the same for everyone. The normal values are lower than 120/80 mm Hg. This is read as '120 over 80'. There have been some disagreements in recent health information. The discussion focuses on the idea that normal ranges may be different based on age. It has been suggested that the recommend

blood pressure values are different for older people. (As people age, the stress they experience in their life may be a reason to recommend lower blood pressure levels).

## **High Blood Pressure**

### **What is a high blood pressure?**

(<https://ihealthlabs.com/Bloodpressure>, (Wade, C. (1975); Childre, D. L., & Wilson, B. (2006); Galton, L. (1973); Kaplan, N. M., & Lieberman, E. (1979))

There are four stages of high blood pressure. The stages are elevated blood pressure, hypertension stage 1, hypertension stage 2, and hypertension crisis. The most common type of high blood pressure is known as essential hypertension. It consists of the four stages of blood pressure stated before. It is the condition for 90-95% of the people who have high blood pressure.

### **Elevated**

Elevated blood pressure is when readings are about 120-129 over less than 80. The top number is the pressure when the heart is contracting. That is systolic pressure. The bottom is when the heart is relaxing between heart beats. That is diastolic pressure. People with elevated blood pressure are likely to develop high blood pressure unless lifestyle changes are made.

### **Hypertension Stage 1**

Hypertension Stage 1 is when blood pressure is from 130-139 over 80-89. The top number is the pressure when the heart is contracting. The bottom is when the heart is relaxing between heart beats. At this stage of high blood pressure, doctors will suggest lifestyle changes. They may also suggest blood pressure medicine based on your risk of heart disease, heart attack, and stroke.

### **Hypertension Stage 2**

Hypertension Stage 2 is when blood pressure is around 140/90 or higher. At this stage of hypertension, doctors will suggest a blend of medicine and lifestyle changes. These changes decrease the risk of stroke, heart attack, heart disease, and kidney failure.

### **Hypertensive crisis**

This stage of high blood pressure requires medical attention. If blood pressure readings suddenly exceed 180/120, wait five minutes and test your blood pressure again. If your readings are still high call your doctor or 911. If symptoms such as

chest pain, hard time breathing, numbness, a change in vision, or hard time speaking, are occurring with the high reading, call 911 right away.

### **Is high blood pressure worse than low pressure?**

(<https://www.cheatsheet.com/health-fitness/which-is-more-dangerous-high-blood-pressure-or-low-blood-pressure.html/>)

Generally, high blood pressure is more worrisome than low blood pressure. This is because problems from high blood pressure can lead to lasting damage to the body. The damage comes from health problems like strokes, heart attacks, heart disease, or kidney failure. Low blood pressure is a concern too though. It can cause dizziness and fainting which could result in serious injury from falling. Conditions depend on the symptoms and the person. Factors such as age, race, and gender play a role too.

### **When do men start to see an increase in blood pressure? Are men more likely to have high blood pressure than women?**

([https://www.heart.org/idc/groups/heart-public/@wcm/@sop/@smd/documents/downloadable/ucm\\_319587.pdf](https://www.heart.org/idc/groups/heart-public/@wcm/@sop/@smd/documents/downloadable/ucm_319587.pdf))

Men and women may see an increase in blood pressure levels around the age of 40. It is important to note that high blood pressure can start at an earlier age though. If a person has a chronic disease like sleep apnea or diabetes, their chances of having high blood pressure increases. Until about age 64, high blood pressure is more common in men. This changes around 65 when high blood pressure is more common in women.

### **When do women start to see an increase in blood pressure?**

([https://www.heart.org/idc/groups/heart-public/@wcm/@sop/@smd/documents/downloadable/ucm\\_319587.pdf](https://www.heart.org/idc/groups/heart-public/@wcm/@sop/@smd/documents/downloadable/ucm_319587.pdf))

Women and men may see an increase in blood pressure levels around the age of 40. High blood pressure can start at an earlier age. This is more common among men though. If a person has a chronic disease like sleep apnea or diabetes, their chances of having high blood pressure increases. Until about age 64, high blood pressure is more common in men. This changes around 65 when high blood pressure is more common in women. African American women aged 65 have the highest rate of high blood pressure.

### **How many women/men between the ages of 35-44 have high blood pressure? Can young people have high blood pressure?**

([https://www.heart.org/idc/groups/heart-public/@wcm/@sop/@smd/documents/downloadable/ucm\\_319587.pdf](https://www.heart.org/idc/groups/heart-public/@wcm/@sop/@smd/documents/downloadable/ucm_319587.pdf))

High blood pressure begins to rise around the age of 40 for most people (men and women). It is important to note that high blood pressure can start at an earlier age though. If a person has a chronic disease like sleep apnea or diabetes their chances of having high blood pressure increases.

By the age of 35 to the age of 44, about 20% of women will have high blood pressure. About 25% of men between the ages of 35-44 will have high blood pressure.

### What is high blood pressure called?

(Wade, C. (1975); Childre, D. L., & Wilson, B. (2006); Galton, L. (1973); Kaplan, N. M., & Lieberman, E. (1979))

High blood pressure is called hypertension. Low blood pressure is called hypotension.

### Low Blood Pressure

Is there such a thing as low blood pressure? What is low blood pressure? Is it possible to have low blood pressure (i.e., hypotension)? If so, what would be considered a low blood pressure reading?

(<https://www.webmd.com/heart/understanding-low-blood-pressure-basics#1>)

Low blood pressure is a blood pressure reading of less than 90/60. Severely low blood pressure can be a sign of an underlying problem, particularly in the elderly. It may cause low blood flow. Low blood flow does not provide the body with enough oxygen to carry out its normal functions. This can result in damage to the heart, brain, and other important organs.

What is bad about low blood pressure? (<https://www.webmd.com/heart/understanding-low-blood-pressure-basics#1>, <https://www.healthline.com/health/hypotension#types>)

In healthy individuals, low blood pressure without any symptoms is not usually a concern. Low blood pressure with symptoms can be a concern as it can cause dizziness, weakness, fainting and a risk of injury from falls. Severely low blood pressure can be a sign of an underlying problem, particularly in the elderly. It may cause low blood flow. Low blood flow does not provide the body with enough oxygen to carry out its normal functions. This can result in damage to the heart, brain, and other important organs.

### What are symptoms of low blood pressure?

(<https://www.heart.org/en/health-topics/high-blood-pressure/the-facts-about-high-blood-pressure/low-blood-pressure-when-blood-pressure-is-too-low>, Childre, D. L., & Wilson, B. (2006))

Low blood pressure symptoms include dizziness, fainting, blurred vision, fatigue, or lack of concentration. Severely low blood pressure may cause insufficient blood flow. Low blood flow does not provide the body with enough oxygen to carry out its normal functions. This can result in damage to the heart, brain, and other important organs. These conditions are especially concerning for elderly people.

### Systolic/Diastolic

**What are the two types of blood pressure?**

**What number is high/low? What is the difference between systolic and diastolic?**

**What does the top/bottom number mean?**

(Wade, C. (1975); Childre, D. L., & Wilson, B. (2006); Galton, L. (1973); Kaplan, N. M., & Lieberman, E. (1979))

Systolic is the top number; it represents the maximum pressure in the blood vessels as the heart contracts. The heart contracts to pump blood to the body from the heart. Diastolic is the bottom number; it represents the minimum pressure of blood in the arteries, or maximum relaxation. This is when the heart is relaxing between beats.

**What is more important — the Systolic or Diastolic reading?**

(Galton, L. (1973))

Both readings are important. The systolic number measures your blood pressure during a heart contraction. The diastolic number measures blood pressure between heart contractions or when it is relaxing. The two readings together give a blood pressure reading. If either of them is higher than the recommended normal range (or if both are), they can indicate potential issues.

**Are they independent?**

(Wade, C. (1975); Childre, D. L., & Wilson, B. (2006); Galton, L. (1973); Kaplan, N. M., & Lieberman, E. (1979))

Systolic and diastolic readings are not independent. They are opposite functions of the heart, contracting and relaxing. These two functions create the pressure in the arteries. Systolic is the top number; it represents the maximum pressure in the blood vessel as the heart contracts. The heart contracts to pump blood to the body from the heart. Diastolic is the bottom number; it represents the minimum pressure of blood in the arteries, or maximum relaxation. This is when the heart is relaxing between beats.

**What is systolic blood pressure?**

(Wade, C. (1975); Childre, D. L., & Wilson, B. (2006); Galton, L. (1973); Kaplan, N. M., & Lieberman, E. (1979))

Systolic is the top number. It represents the maximum pressure in the arteries as your heart contracts. The heart contracts to pump blood to the body from the heart.

**What is diastolic blood pressure?**

(Wade, C. (1975); Childre, D. L., & Wilson, B. (2006); Galton, L. (1973); Kaplan, N. M., & Lieberman, E. (1979))

Diastolic is the bottom number. It represents the minimum pressure of blood in the arteries, or maximum relaxation. This state is when the heart is relaxing between beats. In other words, diastolic is right before pumping more blood into the system.

**Answers from:**

**Books**

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**Websites**

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