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An Analysis of Patients Undergoing Hip and Knee Arthroplasties in an Accountable Care Organization

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By

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ABSTRACT

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Background. Total hip arthroplasty (THA) and total knee arthroplasty (TKA) are commonly performed procedures, with over one million executed each year in the United States (U.S.) (Steiner et al., 2012). By 2030, THA and TKA are projected to become the most frequently performed elective surgical procedures in the U.S. (Cram et al., 2012; Kurtz et al., 2009). Many of the previous studies on THA and TKA procedures have focused on women, primarily because they are at increased risks of developing knee osteoarthritis and sustaining hip fractures (Cummings et al., 1990; Hedlund et al., 1987; Hinton et al., 1995; Myers et al., 1991; Ray et al., 1997; Schrøder & Erlandsen, 1993; Srikanth et al., 2005). However, there is increasing evidence suggesting that there are differences in postoperative outcomes between male and female patients undergoing these procedures (Dalury et al., 2009; Dzupa et al., 2002; Elliott et al., 2003; Endo et al., 2005; Fox et al., 1994; Fransen et al., 2002; Lavernia et al., 2009; Lim et al., 2015; MacDonald et al., 2008; Ritter et al., 2008; Schrøder & Erlandsen, 1993; Trombetti et al., 2002).

Purpose. To compare post-surgical outcomes after THA and TKA procedures between male and female patients part of a physician-led Accountable Care Organization (ACO) participating in the Medicare Shared Savings Program (MSSP) located in the western U.S. and to determine whether this MSSP ACO has been successful in decreasing these patients' total costs of health care.

Methods. The physician-led MSSP ACO provided cost and health risk data on their male and

female beneficiaries who underwent THA and TKA procedures between the years 2016 and 2018. Health risk data only analyzed patients during the postoperative period. One hundred fifty-six men and 291 women were analyzed in this study.

Results. Most patients who underwent THA and TKA procedures between 2016 and 2018 in this MSSP ACO had Medicare insurance (n=329; 81.7%) and were predominantly Non-Hispanic White (n=365; 81.7%). Over three years (2016-2018), men had a greater average risk stratification score than women (17.7 vs. 15.7), indicating that men undergoing THA and TKA procedures have worse overall health than women undergoing the same procedures. Women had greater total costs of health care than men between 2016 and 2017; however, in 2018, men had greater total costs of care than women. When the patient sample was divided by insurance types, Medicare-only patients had lower total costs of care than dual-eligible patients-those with both Medicare and Medicaid insurance- for all three years. Over the three years, the MSSP ACO was successful in decreasing the total costs of care for its male and female patients who underwent THA and TKA procedures (5.66% and 18.4%, respectively). Also, Medicare-only patients' average total cost of care decreased by 11.47%, and dual-eligible patients' average total cost of care decreased by 20.7%.

Conclusion. Male sex/gender was linked with worse health after undergoing THA and TKA procedures. This MSSP ACO was able to decrease its beneficiaries' total costs of care over three years. Thus, MSSP ACOs may show promise in reducing health care costs for their beneficiaries. Policymakers should offer more support to MSSP ACOs for helping them realize increased revenues.

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PREFACE AND INTRODUCTION

Healthcare is in the midst of a seismic shift, moving from a reimbursement model that rewarded providers for the volume of services they provided to one focused on the value patients receive from their care. Now, what does "value" mean? Value-based health care delivers the best possible outcomes to patients for the lowest possible costs. To adapt to the changing healthcare environment, health care organizations must develop strategies aimed at reducing their costs while improving their patients' outcomes.

The basis for this research stemmed from my desire to study high-cost surgical procedures commonly performed across all communities in the United States. My senior thesis analyzes total hip arthroplasty (THA) and total knee arthroplasty (TKA) procedures because there has been significant health reform aimed at improving surgical outcomes and decreasing costs for Medicare beneficiaries undergoing these procedures. Through this original study, I analyzed whether there were any sex/gender-specific differences between male and female patients undergoing THA and TKA procedures between the years 2016 and 2018 in an Accountable Care Organization (ACO) participating in the Medicare Shared Savings Program (MSSP). In addition, I analyzed whether this ACO was able to lower its beneficiaries' total costs of care over these three years.

It is my hope that the work described here will help give researchers, policymakers, and clinicians a baseline set of estimates and a more comprehensive understanding of how patients' sex/gender influences their health care spending and post-surgical outcomes so that the future effects of health care reform can be adequately evaluated and implemented.

CHAPTER 1: LITERATURE REVIEW

SEX VS. GENDER

The *American Medical Association (AMA) Manual of Style* defines sex as the "biological characteristics of males and females" and views gender as "includ[ing] more than sex and serves as a cultural indicator of a person's personal and social identity" (Young, 2007, p. 1). Sex describes the differences between men and women that are primarily biological in origin, and gender describes differences that are produced by social norms regarding the sexes (Buvinić et al., 2006). Simply put, sex is determined by chromosomes, and gender is determined by how one presents oneself in society (American Academy of Orthopaedic Surgeons, 2019).

SEX AND GENDER AFFECT HEALTH OUTCOMES

Even though the concepts of sex and gender can be differentiated using the AMA's definitions, it is difficult to determine whether sex or gender affects a patient's medical condition. Because most peoples' gender identities align with their sex, it is nearly impossible to separate whether an observed difference between men and women is caused by sex or gender (Dusenbery, 2018). In some cases, differentiation is apparent. For example, there is a higher incidence of lung cancer in men than women in the United States (U.S.) because men tend to smoke more cigarettes (Dusenbery, 2018). Clearly, the gender differences between men and women are causing the increased rate of lung cancer in men. Men are not more biologically susceptible to lung cancer; they had differing levels of exposure that caused the disease (Dusenbery, 2018).

On the other hand, there are sex chromosomal abnormalities, such as Swyer Syndrome, that are caused by a gene mutation in the Y chromosome. Because only males have a Y chromosome, Swyer syndrome affects only males (Michala et al., 2008). Clearly, sex differences in males are the cause of Swyer syndrome in men and boys.

However, most health conditions patients experience are not linked to an apparent biological or environmental cause (Dusenbery, 2018). Instead, sex and gender can act independently or synergistically in determining a patient's burden of disease (Krieger, 2003). For example, sex *and* gender differences cause higher rates of osteoporosis in women (Fausto-Sterling, 2005). The level of bone density in individuals is affected by numerous factors such as hormones (Chehab et al., 1997; Damien et al., 1998; Ducy et al., 2000), diet (Boot et al., 1997; Bryant et al., 1999; McKay et al., 2000), physical activity (Messier et al., 2000; Morel et al., 2001; Pettersson et al., 2000), predisposed genetic background (Aloia et al., 1996; Boyden et al., 2002; Dibba et al., 1999; Khosla et al., 2008), vitamin D production (Fujita et al., 1999), and bone-destroying effects of drugs such as cortisone (Larsson, 1969), tobacco (Pocock et al., 1989), and alcohol abuse (Laitinen & Välimäki, 1991). Thus, our experience directly affects our biology (Dusenbery, 2018). For this reason, this manuscript will use the term *sex/gender* while discussing differences between men and women.

WHY IS SEX/GENDER IMPORTANT IN RESEARCH?

One of the major difficulties in determining the impact of sex/gender on the diagnosis and treatment of musculoskeletal (MSK) conditions such as osteoarthritis is rooted in how clinical research is conducted. Even though there have been calls for equal representation for women in clinical trials (National Institutes of Health, 1994), women continue to be underrepresented in many areas of clinical research (Geller et al., 2006; Harris & Douglas, 2000;

Mogil & Chanda, 2005; Murthy et al., 2004; Ramasubbu et al., 2001; Simon, 2005; Stewart et al., 2007; Vidaver et al., 2000). This underrepresentation may be due to the barring of pregnant women from clinical studies for safety purposes, but it may also be due to the differences in recruiting methods that are causing fewer women to be enrolled in them (Vidaver et al., 2000).

However, even if women are represented in clinical studies, many of the studies do not perform a gender-specific analysis because they do not have the statistical power-the ability of a study to detect a difference if a difference truly exists- to allow for this analysis or it was not part of the hypothesis test being studied (Geller et al., 2006, Harris & Douglas, 2000). Ramasubbu et al. (2001) found that only 24.6% of clinical trial participants in studies published by the *New England Journal of Medicine* were women. Among these trials, only 14% performed a gender-specific analysis. Geller et al. (2006) found that among federally-funded studies published in major peer-reviewed journals in 2004, only 37% of the participants were women, and gender-specific analyses were performed in only 13% of the studies. This lack of gender representation and gender analysis could potentially lead to serious consequences. For example, in 2005, 80% of prescription drugs were withdrawn from the U.S. market because they caused statistically greater health risks for women than men (Simon, 2005). Thus, what is suitable for men does not seem to be necessarily ideal for women. However, it is important to note that underrepresentation in clinical studies does not only pertain to women. According to the American Academy of Orthopaedic Surgeons (2019), males have not been included in clinical studies analyzing osteoporosis or hip fractures. Historically thought of as a "disease of postmenopausal women," osteoporosis also affects men, who typically develop this disease ten years later than females (American Academy of Orthopaedic Surgeons, 2019).

PREVALENCE OF THA AND TKA PROCEDURES

Total hip arthroplasty (THA) and total knee arthroplasty (TKA) procedures have a high prevalence, with over one million performed each year in the U.S. (Steiner et al., 2012). By 2030, THA and TKA are projected to become the most common elective surgical procedures performed in the United States (Cram et al., 2012; Kurtz et al., 2009). Furthermore, TKA and THA ranked seventh and twelfth, respectively, among the most common procedures performed by orthopedic surgeons in 2003 (Garrett et al., 2006). The increase in the prevalence of THA and TKA procedures performed are attributed to the aging of the "Baby Boomers," higher rates of diagnosis and treatment of advanced arthritis, and growing demand for improved mobility and quality of life (Maradit et al., 2015). Evidence suggests that there may be differences in patient outcomes after receiving THA and TKA procedures due to sex/gender differences in the anatomy of the hip and knee joints and underlying disease conditions (Rand et al., 2003). For example, men display larger knee cartilage volumes and surface areas (Faber et al., 2000) and have taller and narrower pelvises than women (Wang et al., 2004) (Appendix 1). However, even with the presence of surgical outcome differences, most patients achieve significant long-lasting improvements with THA and TKA procedures.

WHY IS SEX/GENDER IMPORTANT IN ORTHOPEDIC SURGERY IN THE UNITED STATES?

Even though the utilization rates of THA and TKA are increasing at an unprecedented rate, there exist sex/gender differences between male and female patients undergoing these two procedures due to the interplay of biologically determined and socially derived differences between them. For example, women are usually older than men when undergoing THA and TKA procedures (Figure 1).

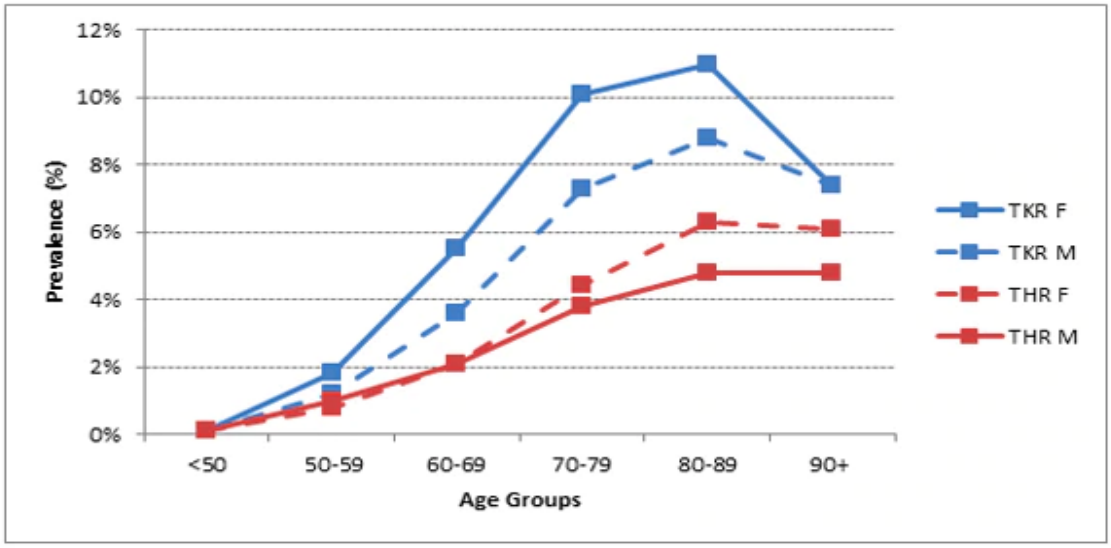

Figure 1. Prevalence of Total Knee Replacement (TKR) and Total Hip Replacement (THR) by Race and Age. (Maradit-Kremers et al., 2015).

As discussed later in this chapter, sex/gender plays a crucial role in orthopedic surgery, particularly in the delivery of THA and TKA procedures to patients. Sex/gender differences affect every stage of a patient's disease process, from increasing the risk of developing a musculoskeletal (MSK) disease to increasing the revision and mortality rates after undergoing THA and TKA procedures. For THA and TKA procedures, revision surgeries are performed to replace implants, either hip or knee, that are no longer functioning properly (Merriam-Webster, 2020). These sex/gender differences between men and women also affect access to, quality of, and costs associated with receiving THA and TKA procedures. Because of the substantial increase in demand for THA and TKA procedures, it is expected that the sex/gender disparities faced by patients will be exacerbated; therefore, attention will be given to THA and TKA procedures. The discussion will now move to analyze the sex/gender differences between male and female patients undergoing THA and TKA procedures.

Sex/gender is vital in orthopedic surgery because the MSK systems of males and females are different. For example, women have less muscle mass and different muscle fiber composition than men (American Academy of Orthopaedic Surgeons, 2019). If men and women have different MSK systems, why would orthopedic surgeons apply a "one size fits all" mindset to orthopedics?

JOINT ARTHROPLASTY VS. JOINT REPLACEMENT

Before discussing the sex/gender differences between men and women undergoing THA and TKA procedures, it is crucial to understand the differences between joint arthroplasty and joint replacement. Arthroplasty means "the surgical repair of a joint," and it is a surgical procedure in which a patient's arthritic or damaged joint is removed and replaced with a metal, plastic, or ceramic device called a prosthesis (Stanford Health Care, 2019). Total joint replacement is a type of arthroplasty (Stanford Health Care, 2019). Thus, this manuscript will use the words "replacement" and "arthroplasty" interchangeably when discussing the sex/gender differences in hip and knee arthroplasty procedures. Also, for this manuscript, total joint arthroplasty encompasses THA and TKA procedures. However, it is important to note that replacement surgery can be performed on other joints, as well, including the ankle, wrist, shoulder, and elbow.

Numerous studies presented in this manuscript analyze the sex/gender differences between male and female patients undergoing THA or TKA procedures. Thus, a brief discussion of total hip replacement and total knee replacements is needed to ensure that readers understand what procedures are being discussed in the studies. After addressing total hip replacement and total knee replacement surgical procedures, the discussion will move to talk about the sex/gender differences between men and women undergoing THA and TKA procedures.

TOTAL HIP REPLACEMENT VS. PARTIAL HIP REPLACEMENT

Hip replacements are divided into two types: total hip replacement (THR) and partial hip replacement. The human hip is composed of the femoral head (single ball), which is the upper end of the femur and the acetabulum (joint socket), which is part of the pelvic bone (Figure 2).

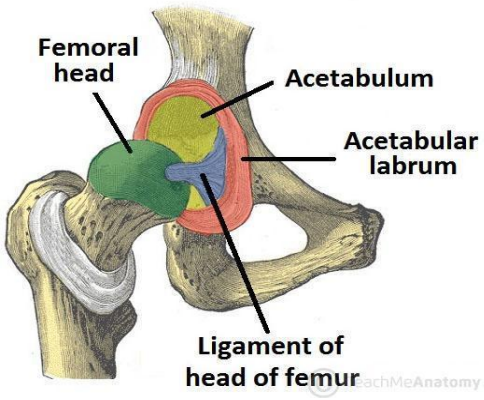

Figure 2. The Articulating Surfaces of the Hip Joint-Pelvic Acetabulum and Head of the Femur (TeachMeAnatomy, 2019).

The bone surfaces of the femoral head and acetabulum are covered with articular cartilage, a smooth tissue that cushions the ends of the bones and enables them to move easily. In a THR, the femoral head and articular cartilage are removed and replaced with prosthetic components. However, in a partial hip replacement, only the patient's femoral head is removed and replaced with a prosthetic femoral head (Figure 3).

Figure 3. The Difference Between a Partial Knee Replacement and a Total Knee Replacement (Khoo Teck Puat Hospital, 2019).

TOTAL KNEE REPLACEMENT VS. PARTIAL KNEE REPLACEMENT

Like hip replacements, knee replacements can be divided into two categories: total knee replacement and partial knee replacement. The knee is separated into three main compartments: the medial tibiofemoral compartment (inner half of the knee), the lateral tibiofemoral compartment (outer half of the knee), and the patellofemoral compartment (behind the knee cap) (Figure 4).

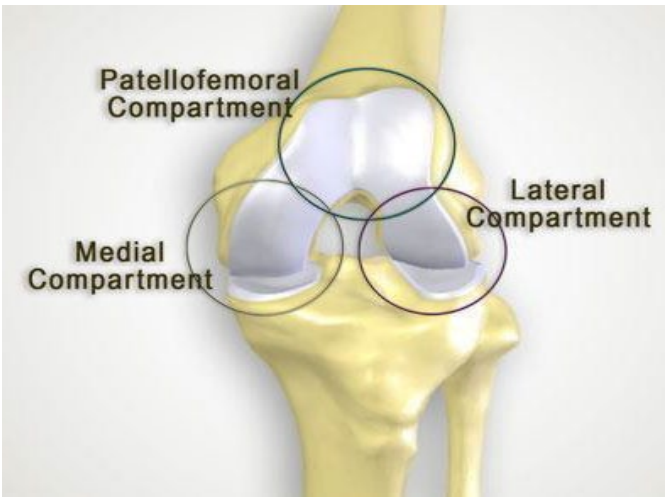

Figure 4. The Three Compartments Inside the Knee (Hoffman Arthritis Institute, 2019).

In a TKA procedure, all three compartments are removed and replaced with a prosthesis, while in a partial knee replacement, only one knee compartment is removed and replaced with a new prosthesis (Figure 5).

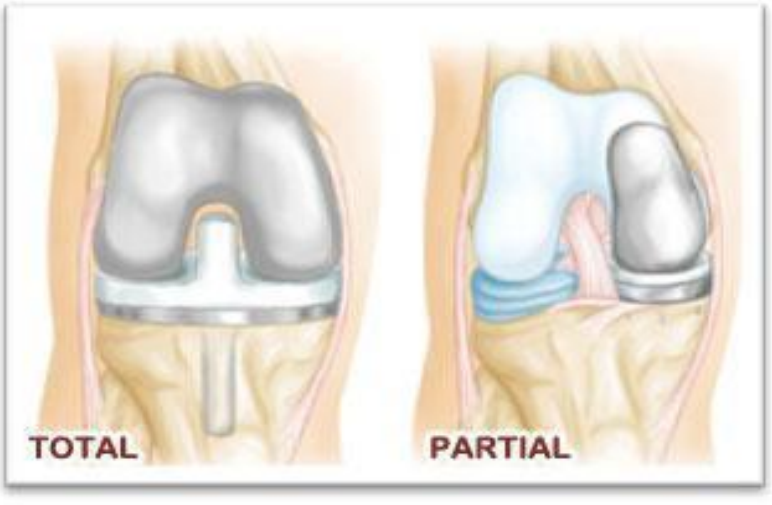

Figure 5. Difference Between Total Knee Replacement and Partial Knee Replacement (Khoo Teck Puat Hospital, 2019).

WHAT IS OSTEOARTHRITIS?

Osteoarthritis, sometimes referred to as degenerative joint disease or degenerative arthritis, is a chronic (long-term) disease. In healthy joints, cartilage covers the ends of each bone

and provides a smooth, gliding surface for joint motion. Cartilage acts as a cushion between the bones. However, in osteoarthritis-stricken joints, cartilage breaks down, causing pain, swelling, and problems moving the joint (Arthritis Foundation, 2019).

As osteoarthritis worsens over time, bones may break down and develop growths called spurs. Bits of bone or cartilage may chip off and float around in the joint. In the body, an inflammatory process occurs and cytokines (proteins) and enzymes develop that further damage the cartilage. In the final stages of osteoarthritis, the cartilage wears away, and bone rubs against bone, leading to joint damage and more pain (Arthritis Foundation, 2019).

Osteoarthritis is the most common chronic joint condition, affecting approximately 27 million Americans (Arthritis Foundation, 2019). In the U.S., osteoarthritis is one of the leading causes of disability. Apart from being the most common form of arthritis, it affects people from a broad age group, especially those aged 65 years and above (Boyan et al., 2013).

Osteoarthritis can affect any joint, but it occurs most often in knees, hips, lower back and neck, small joints of the fingers, and the bases of the thumb and big toe (Arthritis Foundation, 2019). The prevalence of knee and hip osteoarthritis is high, with 50% of adults developing symptoms of knee osteoarthritis, and 25% developing symptoms of hip osteoarthritis during their lives (Arthritis Foundation, 2019). As seen in Figure 6, osteoarthritis is the most common underlying condition for both THA and TKA procedures.

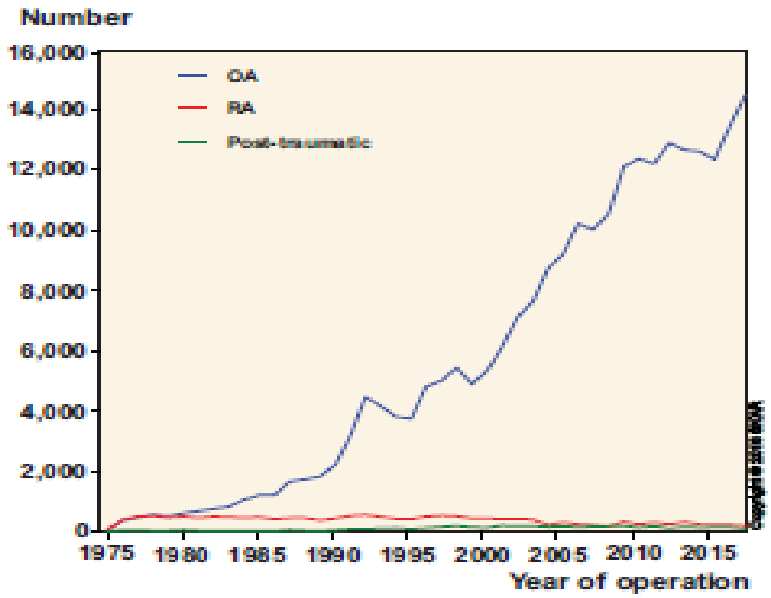

Figure 6. Number of Arthroplasties Performed for Different Diagnoses from 1975 to 2015 (Robertsson, 2019).

SEX/GENDER DIFFERENCES IN PATIENTS UNDERGOING THA AND TKA PROCEDURES

Even though THA and TKA procedures are beneficial treatments for osteoarthritis and degenerative joint disease (de l'Escalopier et al., 2016; National Institutes of Health, 2003), there remains geographical, racial, and sex/gender variations in its utilization (Dunlop et al., 2008; Ibrahim, 2017; Weng & FitzGerald, 2006). These variations in care utilization are complex and encompass patient-level factors (patient's treatment preferences and anatomy), provider-level factors (physician-patient relationship), and system-level factors (access to specialist care) (Ibrahim, 2017).

This chapter aims to show the sex/gender differences between male and female patients undergoing THA and TKA procedures. It will have five main themes: sex/gender differences in the epidemiology of musculoskeletal (MSK) conditions, sex/gender differences in the access to THA and TKA procedures, sex/gender differences in the quality of care of THA and TKA

procedures, sex/gender differences in the cost of THA and TKA procedures, and a discussion on health policy related to these sex/gender differences in these two procedures. This chapter utilizes evidence from peer-reviewed journal articles and government databases to review what is currently known based on these themes.

THEME 1: SEX/GENDER DIFFERENCES IN THE EPIDEMIOLOGY OF MSK CONDITIONS

Differences in patients' sex/gender have been shown to play a significant role in determining the epidemiology of THA and TKA procedures (Hame & Alexander, 2013; Nicolella et al., 2012; United States Bone and Joint Initiative, 2014). The sex/gender differences in the epidemiology of hip and knee arthroplasty procedures have been divided into sex/gender differences in the prevalence, severity, and progression of musculoskeletal (MSK) conditions.

SEX/GENDER DIFFERENCES IN THE PREVALENCE OF MSK CONDITIONS

Musculoskeletal (MSK) conditions, including osteoarthritis, back and neck pain, and osteoporosis, are ubiquitous, affecting individuals across their lifespan. According to the Centers for Disease Control and Prevention (2016), MSK conditions affect one-half of all adults in the U.S. and three-quarters of those aged 65 and older, making these conditions more common than hypertension, diabetes, and cardiovascular disease. However, females bear a disproportionate risk of developing an MSK condition as compared to males. In 2015, 65.6 million females (52.7%) and 58.8 million males (47.3%) reported having at least one MSK condition (Centers for Disease Control and Prevention, 2016). The prevalence of all the major MSK conditions—lumbar back pain, chronic joint pain, arthritis, neck pain, and lower back pain spreading to the knee—was higher in women than in men (Weinstein, Yelin, & Watkins-Castillo, 2018).

Srikanth et al. (2005) conducted a meta-analysis to determine sex/gender differences in osteoarthritis. Although their study established that there was no significant difference in the incidence of certain osteoarthritis types such as hand osteoarthritis between sex/gender, women had a significantly higher prevalence of knee and hip osteoarthritis when compared to men. Similarly, Hame & Alexander (2013) report that osteoarthritis of the knee affects women disproportionately when compared to men. Also, there are specific joints in women that are more susceptible to MSK diseases than in men. For instance, the first carpometacarpal joint (located in the wrist) is more likely to be affected in women aged above 40 when compared to their male counterparts (Sodha et al., 2005). Similarly, Hame & Alexander (2013) found that specific joints in the knee, such as the patellofemoral joint, are more likely to be affected by MSK disease in women than men.

Female sex hormones are the main factor influencing joint health (Liu et al., 1996; Stevens-Lapsley & Kohrt, 2010), and differences in sexual hormones between men and women expose the latter to a higher risk of developing osteoarthritis. Numerous factors are classified as risk factors of osteoarthritis. The main risk factors include previous knee trauma, obesity, age, and female sex (Blagojevic et al., 2010). The higher prevalence of arthritis in women than men is multifactorial: notably, alterations of hormonal levels, especially estrogen, that affect B and T cell homeostasis and interferon regulation, which increases the risk of arthritis (Templeton & Watkins-Castillo, 2014). Estrogen can be found in articular cartilage, which makes it hormonally sensitive.

Women with *Xba*I and *Pvu*II (PX) haplotype sites located in their estrogen receptor (ERα) genes have an increased risk of having osteoarthritis than other women (Albagha et al., 2001; Dong et al., 2008; Gonnelli et al., 2000). A haplotype refers to a set of alleles at linked loci

(location on a chromosome) that are present on one of two homologous chromosomes (Bergstrom, 2001); thus, for any given stretch of chromosomal DNA, an individual will have two haplotypes (Carter et al., 2013). The distribution of the PX haplotype allele is thought to be genetically influenced because women from different geographical localities exhibit different distributions of them (O'Connor, 2006). Women have also been recorded as having less thickness of the cartilage in the distal femur, which may be attributed to the increased risk of osteoarthritis (O'Connor, 2006).

The increased incidence of osteoarthritis also evidences the impact of female sex hormones on osteoarthritis after menopause. Men have a higher prevalence of osteoarthritis than women before the age of 50 (Wilson et al., 1990), but after this age, the prevalence is higher in women (McAlindon et al., 1992; Oliveria et al., 1995). The prevalence increases with age in both men and women, but in women, it increases dramatically around the age of 50 (Wilson et al., 1990; Lawrence et al., 1996; Hernborg et al., 1973), which coincides with menopause. Although there is no consensus about the mechanical role of estrogen in the prevention of osteoarthritis, estrogen decreases cartilage damage and subchondral bone loss in the patella and tibia (Sniekers et al., 2010). As women approach menopause, they have an increased risk for joint arthroplasty, which can be associated with reduced exposure to estrogen, especially after menopause. The estrogen-associated risk for joint arthroplasty is higher for the hip joint than the knee. The use of menopausal hormone therapy was also found to increase the risk of joint arthroplasty. Both estrogen-only and estrogen and progestin therapies elevated this risk (Liu et al., 2009). The onset of menopause in women leads to changes in their hormone exposure and contributes to a heightened risk of osteoarthritis.

Besides the higher risk for osteoarthritis faced by women as a result of their biological differences from men, women may be exposed to even higher risks as a result of the early onset of menopause and menstruation. Studies have shown that a later age at natural menopause is associated with less loss of bone density and a reduced risk of osteoporosis and fracture (Kritz-Silverstein & Barret-Connor, 1993; Parazzini et al., 1996; Van Der Voort et al., 2003). Also, Hellevik et al. (2017) established a negative relationship between older age at menarche (the first occurrence of menstruation) and the risk of joint replacement. Although the researchers did not have a conclusive explanation for this relationship, they speculated that early age of menarche was associated with chronic and widespread MSK disorders. However, the age of menarche only influenced TKA and was not associated with THA (Hellevik et al., 2017). Interestingly, Starvou et al. (2002) observed that women who were PX homozygotes had approximately eight months of delay in menarche compared with those who were PX heterozygotes and subjects without the PX allele. Thus, the PX haplotype polymorphism may be a genetic determinant of the age of menarche.

Unlike Hellevik et al. (2017), who found the age of menarche to have no relationship with THA, Liu et al. (2009) found it to influence both THA and TKA. According to them, women whose age of menarche was 11 years or younger were at an increased risk of osteoarthritis and hip and knee replacement than those reporting menarche at age 12 (not age 12 or greater). Even then, the risk for total joint arthroplasty surgery was higher for the knee joint than the hip joint, though the underlying factors are unclear. One of the explanations for the heightened risk of osteoarthritis with lower age of menarche could be the differences in body weight index (BMI). Liu et al. (2009) reported that women who reported menarche at 11 years and younger had a higher BMI than those reporting at age 12 (not age 12 or greater) (Liu et al.,

2009). Although there exists conflicting evidence, weight gain at a young age has been observed to be a significant risk factor for total joint arthroplasty due to osteoarthritis later in life (Apold et al., 2011; Apold et al., 2014;).

There also exist differences in the morphological characteristics of the distal femur, patella, and proximal tibia between men and women. The ratio of the size of the femoral component to the size of the medial-lateral dimension is larger in women than in men, which exposes their knee joints to increased risks of pain and dysfunction (O'Connor, 2006). A study by Tummala et al. (2018) affirms these findings in a study to determine sex/gender differences in knee joint congruity. The study found that women had a higher contact area and significantly lower congruency indexes in the medial tibiofemoral joint when compared to men. The higher cartilage–cartilage contact area in women was established pre- and post-radiographic osteoarthritis, suggesting a likely contributor to the higher reduction in cartilage volume among women compared to men. The joint incongruence was also seen as contributing to the higher incidence of radiographic osteoarthritis risk among women (Tummala et al., 2018). Sex/gender differences in the formation of joints expose women to a higher risk for osteoarthritis than men.

In addition to the hormonal factors and morphological characteristics, the higher lower-extremity-injury rate and lower muscle strength in women when compared to men are thought to contribute to their higher rate of osteoarthritis (Templeton & Watkins-Castillo, 2014). Hame & Alexander (2013) also report anatomical and kinematic differences to contribute to the higher prevalence of knee osteoarthritis in women when compared to men. Women have narrower thighbones, thinner kneecaps, and larger quadriceps angles than men. This makes them have lower total tibial and patella cartilage volume, which increases the likelihood of defects associated with knee osteoarthritis. The loss of knee cartilage volume among women is also

higher than in men, which increases the development of these defects. Besides, women record greater posterior and anterior shear forces when performing activities such as jumping, which can lead to abnormal stress on the knees and increase the risk of knee osteoarthritis (Hame & Alexander, 2013). Women are also disadvantaged than men in terms of bone, muscle, and cartilage formation, which places them at a higher risk for osteoarthritis.

However, a study by Nicolella et al. (2012) contradicts Hame and Alexander (2013) when explaining the causes of knee osteoarthritis and how they differ between men and women. While the study established limb alignment and quadriceps muscles as the factors influencing the onset and progression of knee osteoarthritis, they did not find any differences between men and women in terms of how these elements affect osteoarthritis. On the contrary, they found obesity to be the main reason for the observed differences in the onset and progression of knee osteoarthritis in men and women. Obesity leads to an increase in the force transmitted to the knee joints. The force can be as high as four times the bodyweight, which makes any slight increase in body weight cause a major increase in this force, assuming no changes in the knee joint anatomy. Increased obesity also influences the levels of cytokines, which is a major risk factor in osteoarthritis. The relationship between obesity and the onset of knee osteoarthritis is higher in women than men, which might explain the higher prevalence of this MSK disorder in them (Nicolella et al., 2012). While obesity increases the risk of osteoarthritis in both male and female patients, this risk is higher in women than in men.

Although women have a higher prevalence of MSK diseases than men, the modes of diagnosis and treatment do not differ among sex/gender (Hame & Alexander, 2013; O'Connor, 2006). For instance, knee osteoarthritis is diagnosed by assessing pain history, stiffness, crepitus (abnormal popping sound in a joint), and swelling. Radiographic evaluation is also carried out to

determine the extent of the damage. On the other hand, treatment may involve non-operative management (i.e., activity modification and anti-inflammatory medication) or TKA surgery. There are no differences in the diagnosis between sex/gender, although the effectiveness of the treatment methods used has not been studied adequately (Hame & Alexander, 2013). The diagnosis and actual treatment of osteoarthritis do not differ between men and women, which implies that other factors cause the sex/gender disparities in its prevalence.

One possible explanation for the increased prevalence of osteoarthritis in women could be that women and men have different psychosocial exposures (i.e., divorce, highly competitive work situation, prolonged illness). According to the National Research Council and Institute of Medicine (2001), workplace psychosocial exposures are known to be risk factors for MSK symptoms. Research findings on the relationship between work-related MSK disorders and psychosocial exposures vary, and its mechanisms are debated, but increasing evidence of this relationship has been reported (Lundberg, 2002; Bernard et al., 1997). It is believed that psychosocial factors affect stress responses and induce MSK pain through them, either directly or indirectly (Baek et al., 2018). Bonger et al. (1993) argue that psychosocial factors in the workplace induce stress symptoms, which may lead to MSK symptoms through increased muscle tension. For example, these researchers found that psychosocial factors have a direct effect on stress by changing individuals' postures through stress.

Hooftman et al. (2005) observed that for both desk and assembly workers, women reported greater job demands and less job control than men, and Josephson et al. (1999) reported a positive association between high physical workloads and psychosocial stressors in occupations dominated by women. Also, women have a much higher risk of exposure to psychosocial stressors, such as gender-based discrimination and sexual harassment in their

workplaces than men (Gutek, 2001). Thus, women's increased exposure to workplace psychosocial stressors may cause them to have a greater prevalence of musculoskeletal disorders than their male counterparts.

Another potential explanation may be that women may have different responsibilities outside of the workplace, such as a heavy domestic workload (Strazdins & Bammer, 2004). Studies have found that women perform household-related tasks (e.g., cleaning & laundry) more often than men, which may lead to a greater daily burden on their musculoskeletal system (Messing et al., 2003; Treaster & Burr, 2004). In other words, women's increased paid and unpaid demands may lead to more stress on their MSK system, causing them to experience more MSK symptoms than men.

Finally, the increased prevalence of MSK disorders in women may be a result of physiological differences in the biology of their muscles, tendons, and ligaments (Punnett & Herbert, 2000). Considering the significant adverse impact of osteoarthritis on quality of life and health outcome measures, the disproportionate prevalence in women poses a major challenge in the achievement of equality in health care provision (Boyan et al., 2013). In other words, women's increased susceptibility to MSK disorders may lead to disparities in the quality of care they receive.

SEX/GENDER DIFFERENCES IN THE SEVERITY OF MSK CONDITIONS

In addition to a greater prevalence of osteoarthritis, women have more severe musculoskeletal (MSK) conditions compared to men, often reporting more substantial reductions in function and quality of life (Zhang et al., 2010). According to the United States Bone and Joint Initiative (2014), women report having greater MSK pain than men. In 2012, 56% of adult

women self-reported MSK pain as compared to 51% of adult men (Templeton & Watkins-Castillo, 2014).

Studies have found that women experience worse symptoms of arthritis (Blagojevic et al., 2010; O'Connor, 2006; Petterson et al., 2007; Srikanth et al., 2005), report worse symptoms than men with similar radiographic severity (Cho et al., 2010), and have more significant hip degeneration (Boyer et al., 2008) compared to men. The high prevalence of osteoarthritis among women implies that their quality of life is worse than that of men. Also, more women report that their arthritis prevented them from performing daily activities such as feeding, dressing, toileting, and bathing (Katz et al., 1963; Katz & Akpom, 1976).

Women have different gait patterns in response to osteoarthritis. According to Debi et al. (2009), although there is no difference in walking speed between men and women with knee osteoarthritis, there are significant differences in their gait cycles. Women recorded reduced single leg support phase (SLS), which measures the time that the bodyweight is entirely supported by one leg and enhanced double leg support phase (DLS), indicating the phase in the gait cycle when the weight is distributed between the two feet, as compared to men. The foot placement angles of male participants also led to a decline in the weight placed on the joints affected by the knee. Debi et al. (2009) demonstrate that the toe out angle gait parameter may be used as a measure of the functional severity of knee osteoarthritis in males while the SLS gait parameter could be used for females. Thus, the differences in the strategies adopted by men and women with knee osteoarthritis in coping with pain and pressure on joints may be attributed to the differences in the severity of symptoms between the two sexes/genders. Surprisingly, there were no significant pain differences between sex/gender in their study; however, the researchers

do note that females always reported higher levels of pain compared to males and the *p*-values for the pain category was close to the significant threshold ($p \leq 0.05$)

McKean et al. (2007) also observed that moderate knee osteoarthritis is associated with differences in certain gait biomechanics in females that do not exist in males. They found that females with osteoarthritis generate less torque at the knee and ankle and less range of motion at the knee, while males with osteoarthritis have mechanics closer to those of males without osteoarthritis (healthy males). Also, McKean et al. (2007) measured osteoarthritis severity using the Kellgren and Lawrence (KL) system, which is a standard method of classifying the severity of knee osteoarthritis (Petersson, 1997). A KL classification Grade 1 demonstrates doubtful narrowing of the joint space with possible osteophyte formation, Grade 2 shows possible narrowing of the joint space with definite osteophyte formation, and Grade 3 indicates distinct narrowing of joint space, moderate osteophyte formation, some sclerosis, and possible deformity of bony ends (Kellgren & Lawrence, 1957). The researchers found that significantly more females had a KL score of 1 (less severe osteoarthritis state), while more males had scores of 2 and 3 (more severe osteoarthritis), indicating that the women analyzed in their study were at an earlier stage of their osteoarthritic disease. Even though the women with osteoarthritis were in an earlier stage of their disease, they exhibited biomechanics more consistent with osteoarthritis gait than their male counterparts. This means that females with osteoarthritis may be altering their gait patterns either earlier in the disease process or to a greater extent than males with osteoarthritis as a mechanism to alleviate pain, pointing to the possibility that women experience more severe symptoms of knee osteoarthritis than men.

Interestingly, other studies have reported that the level of disease severity alone does not explain women's advanced adverse outcomes in osteoarthritis. According to Boyan et al. (2013),

differences in pain between men and women may be caused by neurological factors. For example, the serotonergic-noradrenergic pathway, a descending analgesic pathway, descends from the brainstem to the hypothalamus and cortical structures and modulates sensory input from the primary afferent fibers and projection neurons in the dorsal horn of the spinal cord (Millan, 2002). This neurological pathway leads to the release of serotonin, norepinephrine, and endogenous opioids that inhibit the release of excitatory neurotransmitters such as glutamate (Lee et al., 2011). The serotonergic-noradrenergic pathway is activated in response to a noxious stimulus (tissue-damaging event) (Loeser & Treede, 2018). Once activated, this pathway causes a widespread decrease in pain sensitivity. According to Lee et al. (2011), patients who have chronic pain syndromes like osteoarthritis often have impaired or absent descending analgesic activity. Also, Zubieta et al. (2002) found distinct differences between men and women in pain-related activation of brain mu-opioid receptors, which suggests that the interactive effects of the opioidergic system with gonadal hormones may be an important determinant of sex-based differences in pain sensitivity. Thus, sex/gender differences in pain sensitivity may reflect differences in how pain is biologically transmitted within the brain.

A study conducted by Tsai (2007) found that female elders reported significantly greater osteoarthritis pain disturbance and tended to have more depressive tendencies than males and that these depressive symptoms were the cause for their increased osteoarthritis pain. However, the general pain literature does not support the conclusion that depression is an explanatory factor for osteoarthritis pain (Manninen et al., 1996). Hence, psychosocial variables may contribute to the sex/gender differences in the severity of MSK diseases, but further research is required.

Women's more severe MSK symptoms may be influenced by their unwillingness to undergo total joint arthroplasty procedures. Demiralp et al. (2019) found social support to play a significant role in determining whether patients undergo THA and TKA procedures. Their study found that having a healthy spouse/partner enhances total joint arthroplasty utilization. However, the association was only statistically significant in men and not women. This is an indication that men may benefit from more social support from their partners/spouses than women.

Demiralp et al. (2019) also found that family dynamics also impacted women's willingness to undergo total joint arthroplasty procedures. Women who had children aged under 18 years were less likely to undergo surgery than those with children above this age. Elderly women who lacked household assistance in their homes had lower odds of receiving total joint arthroplasty when compared to those who had assistance from their children at home. On the contrary, there was no relationship between household support from children and the odds of having total joint arthroplasty procedures among men (Demiralp et al., 2019). These findings indicate that familial factors influence an individual's propensity to undergo total joint arthroplasty procedures, but the influence varies between sex/gender. Social support factors and family dynamics are more likely to limit women's willingness to undergo total joint arthroplasty procedures than men, which may cause women to approach surgeons at more advanced stages of MSK diseases than men.

The lower willingness to undergo THA and TKA procedures among women is also evident in the options they are willing to explore. Notably, more women than men accept continued functional decline. This phenomenon can be attributed to social relations that limit women's willingness to accept medical treatment. Women play the role of primary caregivers in the family setting. Consequently, they perceive the risk of surgery and disruption to their lives

more highly than men. Their perception of surgery risk and disruption of their role as caregivers is so significant that they are willing to accept continued pain as an alternative (Novicoff & Saleh, 2011). Women consider surgery to have a larger impact on their personal lives than men, which makes them less likely to undergo it. Besides, they rarely consult their partners when they are feeling pain because they fear that they would cause them to worry. Instead, women seek advice from their friends, which rarely results in them seeking medical attention. Thus, the societal roles assumed by women make them perceive surgery as highly inconvenient, making them prefer living in pain to undergoing total joint arthroplasty procedures.

Women also feel that reporting pain may amount to wasting physicians' time or lead to them being called out for unhealthy behaviors such as smoking or being overweight (Judge et al., 2010). This finding was only specific to female patients. Why might female patients feel this way when they interact with their medical providers? Modern medicine adopted the idea that there was a direct relationship between a noxious stimulus and the pain it caused, which is known that the specificity theory of pain (Dusenbery, 2018). Once this idea gained traction in American medical schools in the early twentieth century, pain that could not be explained by a physical ailment was considered patient hysteria by healthcare providers. In other words, chronic pain that was not a result of an observable pathology was usually assumed to be mediated by psychological mechanisms (Dusenbery, 2018). Historian Marcia L. Meldrum writes, "Those who suffered from unexplained chronic pain syndromes were often regarded as deluded or were condemned as malingerers or drug abusers" (Dusenbery, 2018; pgs. 148-149). According to Dr. Daniel Clauw, director of the Chronic Pain and Fatigue Research Center at the University of Michigan, explained that a couple decades ago, "if you went to a doctor with chronic pain in any particular region of the body and they couldn't find anything wrong in that area of the body, they

would have a tendency to then blame the patient: 'there's nothing wrong with you, you're stressed, it's a psychiatric problem.'" They'd offer "any misattribution for those symptoms" rather than tell them the basic truth: "that we just don't understand pain well enough yet" (Dusenbery, 2018; pg. 149).

Lastly, women's lower exposure to information about total joint arthroplasty procedures and greater fear of undergoing surgery make them less likely to opt for total joint arthroplasty than men. Women's lack of adequate information about total joint arthroplasty procedures contributes to their high fear levels, which deters them from pursuing total joint arthroplasty until their MSK diseases have progressed to advanced stages. These delays in conducting total joint arthroplasty procedures amongst women exacerbate their MSK symptoms (Al-Taiar et al., 2013). Volkmann & Fitzgerald (2015) found that women have less accurate perceptions about TKA outcomes compared to men, which may lead them to have greater anxiety about undergoing surgery compared to men (Karlson et al., 1997). To determine TKA outcome perceptions, Volkmann & Fitzgerald (2015) asked patients to describe the outcomes that they expected for a typical TKA patient after full recovery from surgery and compared these expectations with observed outcomes from an external reference used in a previous study.

SEX/GENDER DIFFERENCES IN THE PROGRESSION OF MSK CONDITIONS

In addition to the severity of symptoms, Cho et al. (2010) reported a faster osteoarthritis symptom progression in women than in men. The faster progression of osteoarthritis symptoms in women is attributed to the sex/gender differences in cartilage volume loss. The researchers argue that apart from women having less tibial and patella volume than men, women are more likely to experience cartilage defects. Over time, women lose more knee cartilage volume than men, leading to an increased progression of tibiofemoral cartilage defects (Cho et al., 2010).

Hanna et al. (2009) also observed that women lose cartilage faster than men. This difference is thought to be a contributor to the faster progression of knee arthritis in women (Hame & Alexander, 2013).

However, there is conflicting evidence regarding sex/gender differences in symptom progression in osteoarthritis. In a study to determine changes in cartilage thickness among people with osteoarthritis, Eckstein et al. (2009) reported that sex/gender was not a significant factor affecting symptom progression. The researchers argued that the one-year change in radiographic knee osteoarthritis status was not significant. They indicated the possibility that one year was a short time to report conclusively that sex/gender had no role to play, indicating the need to have longer observational periods for conclusive reporting (Eckstein et al., 2009).

Similarly, Bastick et al. (2015) did not find any association between sex/gender and knee osteoarthritis progression. In their study, the researchers conducted a systematic review of 43 articles to determine the prognostic factors for radiographic progression of knee osteoarthritis. They found that baseline knee pain, Heberden nodes (bony enlargements of the last finger joint), Varus alignment, and high levels of hyaluronic acid and tumor necrosis factor (TNF**α**) were the major predictors of knee progression. Varus alignment occurs when the knee is not perfectly aligned and causes patients to develop bowlegs- a condition in which a patient's knees stay wide apart even when their ankles are together (Sharma et al., 2010). Hyaluronic acid is a treatment option for patients diagnosed with knee osteoarthritis (Hermans et al., 2019). TNF**α** controls the homeostasis of matrix synthesis and matrix degeneration in articular cartilage; overproduction of TNF**α** causes articular cartilage matrix degeneration, which leads to knee osteoarthritis pathogenesis (Grunke & Schulze-Koops, 2006). On the contrary, factors such as female sex/gender, former knee injury, quadriceps strength, smoking, and physical activity were not

associated with symptom progression (Bastick et al., 2015). While there is no consensus on the relationship between sex/gender and osteoarthritis symptom progression, Cho et al. (2010) and Hanna et al. (2009) indicate that women are more likely to experience faster osteoarthritis disease progression while no studies in the literature report that males have a faster osteoarthritis progression.

The treatment of osteoarthritis faces numerous challenges despite it being the most common musculoskeletal (MSK) disease (Pelletier et al., 2006). In particular, the disease develops and progresses slowly, making it very difficult to detect in its early stages. Besides, osteoarthritis represents a heterogeneous group of disorders that affects different parts of the body. Most importantly, the diseases lack objective and definitive biochemical markers, which can aid therapeutic and clinical research. At times, osteoarthritis progression may take over 30 years before problems requiring treatment develop (Lane et al., 1997). Although disease-modifying osteoarthritis drugs (DMOADs) have been developed, the process is challenging, given the lengthy clinical trials involved, lack of consensus on the biological markets, and multiple regulatory issues. In fact, the majority of the DMOADs that have been developed fail safety and efficacy tests (Pelletier et al., 2006). Despite the current challenges, major strides have been made, and the diseases can be treated using therapeutic, pharmacological, and surgical alternatives. Even then, treatment is often lifelong (Pelletier et al., 2006). The complexity of osteoarthritis makes it difficult to treat despite the existence of multiple treatment options being available to patients.

THEME 2: SEX/GENDER DIFFERENCES IN THE ACCESS TO THA AND TKA PROCEDURES

Although women bear a larger disease burden of musculoskeletal (MSK) disease than men, they have lower access to total joint arthroplasty treatments, particularly treatments for osteoporosis. In the management of postmenopausal women who have had previous fractures, physicians often adhere to clinical guidelines less than 50% of the time (Feldstein et al., 2003). A Healthcare Effectiveness Data and Information Set (HEDIS) measure of osteoporosis management in Medicare plans found that only 19% of women aged 67 and older who had a previous fracture were given a bone mineral density test or prescription for a drug to prevent or mitigate osteoporosis symptoms in the six months following the fracture in 2004 (U.S Department of Health and Human Services, 2006). There also exists age and racial disparities among women in accessing treatments for osteoporosis. According to Andrade et al. (2003), older women are less likely to be administered osteoporosis treatment than younger women, even though increased aging increases the risk of fractures. Screening and treatment rates for osteoporosis are also lower among postmenopausal African American women than Caucasian women (Mudano et al., 2003).

Women visit physicians for hip and knee MSK disorders more often than men (Hawkwer, 2000; Mota et al., 2012). They are also more likely to undergo total joint arthroplasty procedures than men (Katz et al., 1996). However, the higher rate of utilization of surgical treatment options does not consider the higher rate of prevalence of MSK disorders in women. In the U.S., 44.9 per 1000 women and 20.8 per 1000 men have a potential need for total joint arthroplasty (Hawker et al., 2000). However, when Hawker et al. (2000) considered patients who were willing to undergo total joint arthroplasty, the number of surgical candidates decreased to 5.3 per 1000 women and

1.6 per 1000 men. While these data indicate high underuse of total joint arthroplasty for both men and women, the underuse is three times higher in women than in men (O'Connor, 2006; Novicoff & Saleh, 2011).

What could cause the greater underuse of total joint arthroplasty in women than men? Part of the answer, it seems, is that physicians may be partially responsible for the sex/gender-based disparity in the rates of total joint arthroplasty. Borkhoff et al. (2008) used standardized patients with identical clinical presentations of moderate knee osteoarthritis with chronic knee pain who differed only by sex and found that the odds of an orthopedic surgeon recommending TKA to a male patient was 22 times that for a female patient, and the odds of a family physician recommending TKA to a male patient was two times that for a female patient. It is important to note that no surgeon admitted awareness of gender bias in this study. Other studies have also found that doctors and orthopedic physicians are more likely to recommend total joint arthroplasty to male patients than female patients (Al-Taiar et al., 2013; Hame & Alexander, 2013; Novicoff & Saleh, 2011). Sex/gender bias among health care providers results in women having lower access to total joint arthroplasty as compared to men.

There are three possible explanations for physicians' unconscious biases when recommending total joint arthroplasty surgery to patients. First, the physicians' decisions to recommend total joint arthroplasty may be based on conscious attitudes or overt discrimination based on patients' sex/gender. Some studies observed that physicians take women's symptoms less seriously and attribute their symptoms to emotional rather than physical causes (Bernstein & Kane, 1981; Hame & Alexander, 2013) and refer women less often (Franks & Clancy, 1997) than men for specialty care even when they have a more severe disability. Al-Taiar et al. (2013)

also found that surgeons typically provide management treatment options rather than surgery for female patients compared to males. (Al-Taiar et al., 2013).

A second possible explanation is that the physicians' treatment recommendation practices are a product of an unconscious bias based on patients' sex/gender. Unconscious bias materializes when a patient automatically involuntarily activates a stereotype in the physician's memory (Devine, 1989). These discriminatory acts coming from unconscious biases are not deliberate, and physicians are not aware of them. Physicians are vulnerable to the same unconscious gender biases that are pervasive in the rest of society (Ayres, 2003). Physicians may not recommend total joint arthroplasty to female patients as frequently as males because of their unconscious biases resulting from previous experiences, or they have heard from other physicians that TKA is not as effective for women compared to men. This inappropriate preconception may arise because women typically receive surgery at more advanced stages in their diseases than men **(**Kats et al., 1994; Holtzman et al., 2002; Hame & Alexander, 2013) and those with more advanced osteoarthritis have worse surgical outcomes (Holtzman et al., 2002; Fortin et al., 1999; Petterson et al., 2007)

A third explanation is that despite identical disease symptoms, male and female patients may differ in their presentation styles because of their sex/gender. Women generally present their symptoms to medical providers using a narrative style, speaking more openly and personally about their ailments, whereas men usually present their symptoms using a business-like style, describing their illness in a more factual or reserved manner (Davis, 1988; Birdwell, 1993). This may be because male patients possess greater knowledge about total joint arthroplasty procedures than females (O'Connor, 2006).

It is important to note that the restricted access to essential medical treatment among women is not limited to only total joint arthroplasty. On the contrary, operations such as renal transplantation and coronary artery bypass grafting are performed less frequently on women than on men (Hame & Alexander, 2013; O'Connor, 2006). While more women undergo total joint arthroplasty procedures than men, the rate of those who do not go through these surgeries is also significantly higher in women than men. The higher rate in those not getting total joint arthroplasty among women is attributed to the significantly higher prevalence of osteoarthritis in women compared to men, which was addressed in the previous section. Overall, men are more likely to receive a greater provision of total joint arthroplasty services relative to their needs when compared to women (Judge et al., 2010) and women are more likely to have advanced MSK disorders by the time they are undergoing surgery than men, which may lead to worse surgical outcomes.

Sex/gender differences in willingness to undergo total joint arthroplasty contribute to the failure of women to catch up with men in terms of outcomes after the surgical operation. Although women record greater reductions in MSK pain and improved physical activity postoperatively than men, the overall post-treatment outcomes still fall short from those reported in men. Having more advanced MSK disease at the time of surgery and increased preoperative pain have been blamed for contributing to worse outcomes in women than in men (Lim et al., 2015). Since women access treatment for osteoarthritis when the disease is more advanced than in the case of men, they present with worse MSK symptoms before the operation and worse overall outcomes after surgery. O'Connor (2006) estimated that a one-month additional wait for the total joint arthroplasty procedures leads to an 8% less chance of achieving a better than expected surgical outcome.

THEME 3: SEX/GENDER DIFFERENCES IN THE QUALITY OF THA AND TKA PROCEDURES

Although factors such as seeking treatment at advanced disease stages often cause worse total outcomes for women than men, women record greater improvements in pain and physical activity after undergoing TKA procedures (Lim et al., 2015). According to Lim et al. (2015), both men and women record significant improvements in terms of pain and functionality after undergoing TKA surgery. The researchers report that women record greater improvements than men after THA for end-stage knee osteoarthritis. The increased improvement in men and women is an indication of equal quality of THA and TKA procedures for both sexes/genders (Lim et al., 2015). There is no difference in postoperative recovery between sex/gender in cases where patients had the same level of pre-operative disease severity. Functional improvement after surgery is comparable in both sexes/genders, indicating the equal quality of care offered to men and women (Novicoff & Saleh, 2011).

Even in cases where different outcomes were reported for men and women, they were only in the short run. For instance, Papakostidou et al. (2012) found that women recorded worse scores in the domains of pain and physical activity than men six weeks postoperative. However, the gains leveled out afterward. Similarly, Mehta et al. (2015) did not find any differences in the long-term post-treatment outcomes between men and women after knee arthroplasty. For both function and pain measures, women recorded worse outcomes than men six months after the operation. However, there was no difference in treatment outcomes 12 months after surgery. The differences in the treatment outcomes in the short run can be explained by differences in pre-surgery status between men and women.

Before surgery, women had more disease progression than men. They recorded poorer pain and function scores pre-surgery, which explains their worse outcomes shortly after surgery. As the treatment takes effect, the difference between sex/gender evens out (Mehta et al., 2015). On the other hand, Liebs et al. (2011) established that women recorded better pain, physical function, and stiffness scores in the short-term (three- and six-months follow-ups) than men. However, like Papakostidou et al. (2012) and Mehta et al. (2015), there was no sex/gender difference in these outcomes at 12- and 24-month follow-ups (Liebs et al., 2011). Although women may report worse outcomes than men after surgery, this difference is not sustained in the long run.

The failure rate of THA and TKA procedures is not highly dependent on sex/gender. According to the National Institutes of Health (2003), the influence of sex/gender on revision rates varies from study to study and does not appear to be influenced by sex/gender significantly. For instance, it is reported that two large Canadian and Swedish studies found sex/gender to play no role in influencing the revision rate following THA and TKA procedures. However, American men have been shown to have a greater risk of revision than women. Men also have a higher risk of failure than women. Factors other than sex/gender, such as the surgeon's experience and choice of prosthesis, may have an impact in determining the outcome of surgery (National Institutes of Health, 2003). Thus, the success rate of arthroplasty is not influenced by sex/gender.

Another way of assessing the sex/gender differences in the quality of THA and TKA procedures is assessing the influence of sex/gender on patient satisfaction. Delanois et al. (2018) set out to determine how sex/gender influenced patients' ratings of their experiences after receiving THA procedures. The major factors that determined hospital ratings differed between

men and women. While men were mainly influenced by pain management, women focus more on staff responsiveness. Both men and women considered communication with nurses and doctors an important factor while rating their experience. Despite the differences in factors that exert more influence on patient experience ratings between sex/gender, the overall hospital rating did not differ significantly (Delanois et al., 2018). A review by Okafor & Chen (2019) found mixed results regarding the influence of sex/gender on satisfaction with THA procedures. Many of the studies did not find major differences in the degree of satisfaction between sex/gender (Okafor & Chen, 2019). Although Rolfson et al. (2009) established higher satisfaction in men than women following hip arthroplasty, treatment outcomes were similar. The difference in satisfaction did not reflect the similarity in pain reduction between men and women (Rolfson et al., 2009). Thus, there is no significant difference in the satisfaction with total joint arthroplasty between men and women.

Although there is no major difference in the quality of the total joint arthroplasty procedure between sex/gender, the low access of care amongst women implies that the quality of care they receive for knee and hip osteoarthritis is worse than that of men. Although conservative measures — use of pain medication, disease-modifying drugs, and therapy — are the most preferred approaches to treating osteoarthritis, they are only effective in the early-stage and for mild osteoarthritis. On the other hand, patients with severe osteoarthritis, especially in the presence of severe pain and deformity, or in cases where conservative measures have failed, are recommended to undergo total joint arthroplasty (Wood et al., 2013). According to Papakostidou et al. (2012), total joint arthroplasty is the most effective treatment option among patients with medication-unresponsive osteoarthritis. This effectiveness is evident in pain reduction, deformity correction, and improvement of patients' quality of life. Low access to THA and TKA

procedures amongst women when compared to men implies that the care that they receive, especially when their osteoarthritis is not responding to conservative treatment approaches, is not of the highest quality.

THEME 4: SEX/GENDER DIFFERENCES IN THE COST OF THA AND TKA PROCEDURES

Osteoarthritis is a musculoskeletal (MSK) disorder affecting a large proportion of the population. It is a leading cause of long-term disability, which implies high direct and indirect costs. The financial burden of osteoarthritis leads to direct costs in the healthcare system and indirect costs to societies. Given the disparities in the rate of osteoarthritis between men and women, the latter contribute more to the cost burden. Women report more severe knee and hip osteoarthritis, osteoarthritis-related disability, and difficulties in performing daily tasks than men. Although both men and women underutilize arthroplasty, the underuse in women imposes a larger financial burden on the government, insurance companies, individuals, and society than underuse in men (Hawker et al., 2000). Arthroplasty increases work productivity, especially among working-age patients, thus presenting an economic benefit. The societal benefits attained offset the direct surgery costs incurred.

Osteoarthritis is very expensive, considering the long periods of treatment. Losina et al. (2015) estimated that the lifetime direct medical costs for persons diagnosed with knee osteoarthritis were $129,600. Many patients wait for an average of 13 years before they seek TKA procedures, opting to try out non-surgical regimens before embarking on the surgical option. Despite the long waits before a TKA procedure, most of the patients underwent surgery before the age of 65. At this time, most health care costs are incurred by private insurers.

However, patients are likely to have multiple revision surgeries after the age of 65, during which time the costs are incurred by social insurance such as Medicare (Losina et al., 2015). While reporting on the annual costs of treatment of knee and hip osteoarthritis, Gupta et al. (2005) estimated direct costs of $12,200 per annum. Patients with osteoarthritis-related costs attributed to 81% of the total economic burden to indirect costs. Direct costs included the purchase of assistive devices and pain help, while indirect costs included formal and informal lost labor and caregiver time losses (Gupta et al., 2005). Despite the differences in the categorization of costs and different measurement methods in the two studies, indirect costs account for the major economic cost of osteoarthritis.

Women are unfairly affected by the costs associated with osteoarthritis. Gupta et al. (2005) found that women are more likely to report costs associated with osteoarthritis than men. The costs reported were influenced by the state of health and osteoarthritis severity. Consequently, the high likelihood of women to report costs might be as a result of having advanced cases of osteoarthritis and poor health conditions. This is supported by the finding that women, especially in rural areas, reported higher direct costs when compared to men (Gupta et al., 2005). In the study by Ackerman, Livingston & Osborne (2016), women participants reported that they did not undergo THA and TKA procedures due to cost barriers, especially of post-surgical care. In the study, male participants also cited access to private insurance as a major factor influencing access to THA and TKA procedures (Ackerman, Livingston, & Osborne, 2016). In countries such as the U.S., insurance acts as a major determinant of access to health services such as arthroplasty. Lack of insurance presents a major barrier to the U.S. healthcare system. Women are more likely to experience barriers related to health insurance when seeking THA and TKA procedures than men (Hawker et al., 2000). Therefore, women face

cost barriers in THA and TKA procedures because the odds of having these procedures are influenced by health insurance. Medicaid coverage increases the odds of having total joint arthroplasty procedures among people with osteoarthritis. On the other hand, the lack of health insurance reduces the utilization of total joint arthroplasty procedures (Demiralp et al., 2019).

The lower social support received by women seeking total joint arthroplasty procedures when compared to men imposes extra costs of this treatment, which makes it difficult for women to access health services. Total joint arthroplasty surgery leads to reduced mobility, which leads to additional pecuniary and nonpecuniary costs. Having total joint arthroplasty surgery presents an economic decision, which is dependent on the economic cost involved. On the one hand, forgoing a total joint arthroplasty procedure implies that one must live with pain and a certain level of physical dysfunction. These effects often have economic costs related to productivity.

On the other hand, having surgery is an investment that requires direct costs of surgery. When one does not have adequate social support, they may be required to make alternative caregiving arrangements to help them cope after surgery. Such arrangements cost money and increase the cost of surgery. Women have lower social support than men. Consequently, their cost of undergoing total joint arthroplasty procedures is higher because they not only have to pay the direct cost of surgery but must hire caregiving services to carry out household roles during recovery from surgery (Demiralp et al., 2019). With this understanding of the costs of surgery, women incur higher costs to undergo total joint arthroplasty procedures even if the direct costs of operation are standard for both sexes/genders.

THEME 5: HEALTH POLICY

A multitude of factors has contributed to sex/gender inequalities in health care. These factors range from biological, access to and control over resources, and sex/gender-related family and societal dynamics. The negligence of sex/gender often contributes to the sex/gender-based inequities during the planning and implementation of health strategies and policies. Although there are multiple policy efforts aimed at promoting sex/gender equity in health, they often lack a multisectoral approach. Health policies focus primarily on the medical aspects of health care while ignoring other domains. However, such policies have limited effectiveness because they fail to consider factors such as power dynamics in the family setting that prevent women from accessing services in the same way as men. To address these gaps, a multisectoral approach to health policy promotion should be adopted. Health policies should address the social and environmental determinants of sex/gender-based health inequities. The social and economic change should also be pursued as a means of addressing sex/gender-based health disparities (Östlin et al., 2006).

The high disease burden and inequalities evidenced in the THA and TKA procedures have necessitated health policy recommendations to address the issue. Researchers have provided several strategies to address the sex/gender gap in the epidemiology, access, quality, and cost of THA and TKA procedures. Nakua et al. (2015) argue that sex/gender differences necessitate the implementation of sex/gender-based policies in national health policies to address the gap. Appropriate geriatric care policies that consider the existing sex/gender differences should be implemented to address the expected rise in demand as the life expectancy of people increases. The increase in life expectancy is likely to increase the demand for THA and TKA

procedures among the elderly (Nakua et al., 2015). However, the researchers do not offer any specific policy that can be used to address this issue.

To address the sex/gender differences in the cost of THA and TKA procedures, Losina et al. (2015) recommend the expansion of the eligibility criteria for TKA under Medicare coverage. Considering that many patients with osteoarthritis undergo TKA before the age of 65, the treatment is not eligible for Medicare coverage. Expanding eligibility criteria to include younger ages can increase patients' access to THA and TKA procedures by shifting the cost to the government. As the cost burden is shifted to the government, people would change the TKA timing. However, implementing such a policy would necessitate a serious consideration of the potential effects of shifting costs to Medicare (Losina et al., 2015).

LITERATURE REVIEW CONCLUSION

This section set out to assess sex/gender differences in THA and TKA procedures by reviewing the existing literature. The review established major sex/gender-based differences in the epidemiology of hip and knee osteoarthritis in terms of incidence, manifestation, and risk factors. However, there was no difference in the diagnosis and the actual treatment approach between men and women. Differences were also noted in access to THA and TKA procedures, with women having lower access than men in terms of rate of utilization, medical practitioner bias, and access to information. Another sex/gender disparity that was noted in the literature was related to the cost of surgery. Although the direct costs of osteoarthritis did not differ significantly between men and women, the latter incurred higher indirect costs. However, there were no notable sex/gender differences in the quality of THA and TKA procedures. There is a limited focus on health policy targeting the reduction of sex/gender disparities in the treatment of

knee and hip osteoarthritis. Future work should focus on specific policies that can be utilized to address this sex/gender-based health disparity.

SENIOR THESIS RESEARCH STUDY AND QUESTION

My senior thesis provides an original study that analyzes 1) whether there are any sex/gender-specific differences between male and female patients undergoing THA and TKA and 2) whether a physician-led Accountable Care Organization (ACO) participating in the Medicare Shared Savings Program (MSSP) in the western U.S. is successful at lowering the total cost of care for its patients between the years 2016 and 2018. I chose to analyze THA and TKA procedures for my senior thesis project for two reasons. One, there has been significant health reform targeting THA and TKA procedures. A recent payment model, Comprehensive Care for Joint Replacement (CJR), implemented in 2016, focuses on improving the quality of patient care and decreasing health costs for Medicare beneficiaries undergoing THA and TKA procedures by paying a "target price" for all related care and services within a 90-day episode of care, including the post-discharge period (McLawhorn et al., 2017). Two, THA and TKA procedures are among the most frequently performed operating room procedures performed in the U.S. (Fingar et al., 2016). The use of THA procedures is projected to grow 71% by 2030, and TKA procedures are projected to grow 85% by 2030 (Sloan et al., 2018).

Because MSSP ACOs are a relatively new topic in healthcare, and it is difficult to collect longitudinal cost data, there has been a lack of scholarly research on whether MSSP ACOs are true health cost containers. This study is important and relevant because it is the first of its kind to analyze both the sex/gender differences in postoperative outcomes between male and female patients undergoing THA and TKA procedures and whether an MSSP ACO is reducing the costs of care for its beneficiaries. The following section will briefly explain what MSSP ACOs are,

why they were created, and how they are reimbursed for the services they provide to their beneficiaries.

THE ABCS OF ACOS: ACCOUNTABLE CARE ORGANIZATIONS EXPLAINED

WHAT IS AN ACCOUNTABLE CARE ORGANIZATION?

Accountable Care Organizations (ACO) were created by Section 2706 of the Patient Protection and Affordable Care Act (ACA) to address rising health costs, uneven quality of care, and fragmented care that has plagued the U.S. healthcare system (Fisher et al., 2011). ACOs aim to improve their beneficiaries' experiences of care, improve their beneficiaries' health, and their per capita costs of health care, a conceptual framework called the Triple Aim (Institute for Healthcare Improvement, 2020) (Appendix 2). An ACO is a network of health care providers and hospitals that shares financial risk and medical responsibility for providing team-based, coordinated care to Medicare patients. Health care providers in this network may include physicians, surgeons, pharmacists, nurses, health care assistants, caregivers, lab specialists, psychiatrists, mental health professionals, rehabilitation workers, and other health care specialties. This group of people collaboratively work together to coordinate patient care to obtain maximum care for clients and the group "accepts joint responsibility for health care spending and quality for a defined population of patients" (Song, 2014, pg. 2).

According to Song (2014), the three key characteristics of the ACO are: "joint accountability, accountability for both quality of care and health care spending, and responsibility for the care of a population of people. Joint accountability means that health care providers across specialties, disciplines, and care settings are incentivized to deliver patient care together and coordinate care more effectively. ACO incentives for health care providers are agreed upon at the organizational level in an ACO contract. Together, health care providers and

hospitals take on the financial risks and rewards outlined in the ACO contract. Incentives such as shared cost savings and quality bonuses are based on how the overall organization performs, rather than on the performance of an individual health care provider, practice, or hospital.

Under Medicare's fee-for-service (FFS) payment system, doctors and hospitals are reimbursed for each test and procedure provided for their patients. Doctors and hospitals within ACOs still operate under an FFS system but are incentivized to be more efficient by receiving financial bonuses when they keep the costs of healthcare down. Under ACOs, doctors and hospitals must meet specific quality benchmarks, focusing on disease prevention and carefully managing patients with chronic diseases and multiple comorbid conditions (Burke, 2011).

If the ACO cannot save money, it may be responsible for the investments made to improve its care, such as adding new nurse care managers. An ACO may also have to pay a penalty if it does not meet its performance and savings benchmarks. However, ACOs under the management of physicians or rural providers can apply to receive payments in advance to assist them in building the necessary infrastructure to be able to provide coordinated care – an exception the Obama administration enacted after rural hospitals complained (Blackstone, 2016).

At the center of each patient's care is a primary care physician. For purposes of the Medicare Shared Savings Program (MSSP), a primary care physician is defined as a physician who has primary specialty designation of internal medicine, general practice, family practice, or geriatric medicine, or for services provided in federally qualified health clinics (FQHCs) or rural health clinics (RHC) (American Academy of Family Physicians, 2011). In theory, having primary care physicians act as the centerpiece of health care delivery ensures that patients are receiving the right care at the right time while avoiding unnecessary duplication of medical services and preventing medical errors. When an ACO achieves in delivering high-quality care

and spending health care dollars more wisely, it shares in the cost savings it achieves with the Medicare program. According to the provisions outlined in the ACA or sometimes referred to as Obamacare, each ACO must manage the health care needs of a minimum of 5,000 Medicare beneficiaries for at least three years (Gold, 2015). This minimum requirement was enacted to ensure that there was a large enough sample size in the ACO and an adequate amount of time for the ACO to report meaningful performance measurements to the government (Merlis, 2010).

HMO VS. ACO COMPARISON

Even though Accountable Care Organizations and Health Maintenance Organizations (HMOs), a type of Managed Care Organization (MCO), share many characteristics such as managing risk, building physician networks, and promoting the health of its members and targeting resource utilization (Tabriz et al., 2017), ACOs are different than HMOs. There are three important differences between them, which will be outlined below. This information can also be found in Figure 7, which outlines the differences between ACOs and HMOs.

First, patients enrolled in an ACO are not locked into an integrated network. ACO patients can access health care providers and settings within or outside of the ACO integrated network; thus, patients can choose any primary care physician, specialist, or hospital they want. HMO patients must choose health care providers and hospitals within the network for a certain minimum period. Also, patients enrolled in an HMO must stay within the network, but doctors do not. If a patient's doctor drops out of the network, HMO enrollees cannot see them, which hinders continuity of care. ACOs do not have enrollment lock-in provisions; therefore, patients can seek care freely.

Second, ACOs are not insurance companies; ACOs are provider-led organizations consisting of physicians, hospitals, and other health care providers. Therefore, ACOs do not have

utilization reviews and no pre-approval process. In the HMO model, insurance companies place primary care physicians as "gatekeepers" to control costs and patient care. In this model, primary care physicians are tasked to oversee pre-authorizations and referrals, which controls patients' access to specialists, tests, and hospitalizations. Insurance companies tell primary care physicians what is and is not permitted, limiting benefits and patients' choices of hospitals or specialists. Because ACOs are provider-led, primary care physicians coordinate care through a team approach with patients and other health care providers to create a value-based health care delivery system. Value-based healthcare is a care delivery model in which providers, including hospitals and physicians, are reimbursed based on patient health outcomes (Catalyst, 2017). In a value-based environment, the focus is toward quality, shared risk, and population health management (Health Research & Educational Trust, 2014). ACOs allow providers to utilize the best medical practices and provide health care providers the autonomy to choose the most appropriate path to efficient, high-quality care.

Lastly, ACOs have financial incentives and reimbursement structures centered around quality performance and shared risk. Also, HMOs are full capitation models, placing all financial risk on the providers, who are paid a fixed amount per patient, regardless of whether patients seek care, and regardless of how much care patients may need. If patient care exceeds the pay-per-patient allocated, the providers lose money, not the insurers. This capitation incentivizes managed care, but not quality care. Because of this, critics of HMOs are concerned that HMO physicians may be financially influenced to withhold care from patients. ACOs offer a variety of payment models, such as a modified FFS system, and most ACOS are built on sharing financial risk between providers and insurers. In ACOs, providers are incentivized with shared savings

and bonuses when they successfully meet the required performance focused on increased quality and lower cost of care.

Characteristics	ACO	HMO
Goal	Improve quality of care and reduce costs.	Improve quality of care and reduce costs.
Structure	Provider-led organization.	Insurance-led organization.
Physician role	Primary care physician as a member of the team.	Primary care physician often serves as gatekeeper.
Access	Patients are free to choose provider outside the network.	If patients choose provider outside the network HMOs did not pay for that care normally.
Quality	Includes quality measures that determine pay rates.	Although some HMOs did evaluate patient health outcomes, usually provider members are not held directly responsible for the health of their patients and are not evaluated on their overall effectiveness.
Contracts	Usually single integrated.	Usually fragmented agreement.
Size	Usually small and local.	Large organizations.
Payment	A variety of payment mechanisms, including capitation, fee for service component, combined with shared savings.	Capitation, salary and fee for service.

Figure 7. ACOs vs. HMOs Comparison (Tabriz et al., 2017)

MEDICARE SHARED SAVINGS PROGRAM (MSSP)

The Medicare Shared Savings Program (MSSP) is Medicare's flagship ACO program (Centers for Medicare and Medicaid Services, 2019c). A flagship program is a major program of the government to achieve a certain goal; in this case, decrease health care costs and increase the quality of patient care. MSSP is Medicare's largest ACO program (Muhlestein et al., 2017). An ACO that joins the MSSP can have two "agreement" periods" (each period lasts three years) in track 1 (upside risk only) before moving into tracks 2 or 3 (upside and downside risk). One-sided risk models only have upside risk, which means providers share in savings if spending is below the benchmark but do not have to reimburse payers if payment exceeds the benchmark. Thus, track 1 in the MSSP is a one-sided risk model, while track 2 is a two-sided risk model. Two-

sided risk models have upside and downside risk, which means providers still share in the savings but are also responsible for some of the loss if spending is above the benchmark. It is important to note that the term “MSSP ACO" refers to ACOs that are participating in the MSSP.

CHAPTER 2: METHODS

DATA SOURCE AND STUDY POPULATION

As previously mentioned, the present research aims to analyze whether there are sex/gender-specific differences between male and female patients undergoing total hip arthroplasty (THA) and total knee arthroplasty (TKA) procedures. This study analyzes longitudinal cost data from the years 2016 and 2018 to determine the efficacy of a physician-led MSSP ACO in the western U.S. Among all patients seeking care in this MSSP ACO, between the years 2016 and 2018, patients meeting specific criteria were sampled to analyze whether there were sex/gender differences between male and female patients undergoing THA and TKA procedures.

It is important to note that the data provided by the MSSP ACO were anonymous. The data did not contain any patient identifiers such as name and address, or even the provider's name. Also, the Chief Executive Officer (CEO) of this physician-led MSSP ACO had permitted me to use their data for my senior thesis project. Lastly, I received approval from the Union College Human Subjects Review Committee to use the MSSP ACO's data in my research.

Patients were selected for the study based on having one or multiple of the following Diagnosis Related Group (DRG) codes:

Code 468: "Revision of Hip or Knee Replacement without Complication or Comorbidity"

Code 469: "Major Hip and Knee Joint Replacement or Reattachment of Lower Extremity with Major Complication or Comorbidity (MCC) or Total Ankle Replacement"

Code 470: "Major Hip and Knee Joint Replacement or Reattachment of Lower Extremity without MCC"

These DRG codes indicate the type of procedures the patients within the MSSP ACO had undergone. DRG Codes 468, 469, and 470 represent THA and TKA procedures. The MSSP ACO provided data on the average total cost of care per patient/beneficiary, CMS Risk-Adjusted Factor (RAF) scores, and PHDS (Predicted Hyperglycemic Crisis Death) scores for male and female patients undergoing THA and TKA procedures. To get reimbursed for the services it provides, this organization collects these data and forwards them to the Centers for Medicare and Medicaid Services (CMS).

CMS uses RAF scores to differentiate payments based on the complexity of patient diagnosis. In theory, the higher the RAF score, the sicker the patient is and therefore requires a greater amount of care from health care providers. RAF scores generally range between 0.9 and 1.7 (Yeatts & Sangvai, 2016). CMS RAF scores are normalized to a value of 1.0. Patients with RAF scores less than 1.0 are considered relatively healthy, and patients with RAF scores greater than 1.0 are unhealthy compared to the general population (Yeatts & Sangvai, 2016). CMS RAF scores justify higher payments to health care providers. In other words, these risk scores are used to adjust payments back to the MSSP ACO. CMS RAF scores are reset at the beginning of every calendar year, requiring health care providers to reassess patients' diagnoses and chronic conditions every year.

The data, as presented by the MSSP ACO, did not lend itself to statistical analyses. Specifically, I could not calculate if there was a statistically significant difference between male patients' PHDS risk scores and female patients' PHDS risk scores. Also, I could not determine if there was a statistically significant difference between male patients' average total cost of care and female patients' average total cost of care. To ensure anonymity, the MSSP ACO did not provide me with data that showed their beneficiaries' sex/gender. The MSSP ACO only provided

me with data that contained the average PHDS risk score for both male and female patients undergoing procedures THA and TKA procedures and the total cost of care for these male and female patients over the 2016 to 2018 time period. To conduct statistics on the data, I would need the PHDS risk score and the total cost of care for each patient in the MSSP ACO who underwent THA and TKA procedures; these data would need to be divided by the patients' sex/gender to compare the PHDS risk scores and the total costs of care between male and female patients. Thus, *p*-values could not be calculated to see if there were statistically significant differences between men and women undergoing THA and TKA procedures.

PHDS Risk Stratification Algorithm

To compare the differences in the Predicting Hyperglycemic Crisis Death (PHDS) risk score between male and female patients undergoing THA and TKA procedures, I compared the mean scores for both sexes/genders. As seen in Table 1, a risk stratification score based on a proprietary algorithm used by the MSSP ACO was used to stratify patients' complexities based on their diagnoses, hospital admissions, length of stay in days, readmissions, emergency department (ED) visits, age, drug or alcohol abuse, and behavioral health. The risk stratification algorithm allowed me to analyze whether there were sex/gender differences between male patients and female patients' outcomes after receiving THA and TKA procedures.

Table 1. PHDS Risk Stratification Variables

ID	Parameter	Comments	Conditional Logic
1	Diagnoses	Within the past 12 months	Inclusionary weighted (Coding list)
2	Hospital Admissions	Only for inpatient stays in the last 12 months by Thru date.	Within the past 12 months
3	Length of Stay (days)	Only for inpatient stays in the last 12 months by Thru date.	Weighted per ID2
4	Readmissions	Only for inpatient stays in the last 12 months by Thru date.	Within <=30 days of ID2
5	ED Visits	Only for ED visits in the last 12 months by Thru date.	Within the past 12 months
6	Age		Weighted
7	Drug or Alcohol Abuse	DX Class = (Alcohol-Related Disorders OR Substance-Related Disorders) AND Chronic	DX Coding - Within the past 12 months
8	Behavioral Health	DX Body System = (Mental Health) AND DX Class = (NOT Substance-Related) AND (NOT Alcohol Related) AND (NOT Delirium Dementia …Disorders)	DX Coding Psych (12 months) Hospitalizations (12 months)

*PHDS, Predicting Hyperglycemic Crisis Death. ED, Emergency Department. Inpatient is defined as patients who stay overnight in the hospital. DX is the abbreviation for diagnosis, the determination of the nature of a disease.

A key advantage of using the Predicting Hyperglycemic Crisis Death (PHDS) Risk Stratification Score over CMS's RAF score is that it does not reset every calendar year. The continuity in the PHDS risk stratification score allowed me to compare data over three years (2016-2018). The PDHS risk stratification score accounts for patients' undergoing the above-noted procedures and subsequent care, which may not correspond to the CMS payment calendar.

CHAPTER 3: RESULTS

Between the years 2016 and 2018, 447 patients (156 males and 291 females) met the criteria for inclusion in this study. The criteria for the present study was that patients had to be part of this physician-led MSSP ACO and had to undergo total hip arthroplasty (THA) and total knee arthroplasty (TKA) surgical procedures. Table 2 describes the patient sample population who received THA and TKA procedures within the MSSP ACO between the years 2016 and 2018.

Table 2. Demographic Characteristics of the Patient Population, 2016 to 2018.

Year	2016	2017	2018	Total
Number of Patients by Race				
Non-Hispanic White	122 (81.9%)	124 (83.2%)	119 (79.9%)	365 (81.7%)
Black	12 (8.05%)	8 (5.37%)	14 (9.40%)	34 (7.61%)
Hispanic	7 (4.70%)	7 (4.70%)	4 (2.68%)	18 (4.03%)
Asian	5 (3.36%)	6 (4.0%)	4 (2.68%)	15 (3.36%)
Other	3 (2.01%)	3 (2.01%)	3 (2.01%)	9 (2.01%)
Unknown	0 (0.00%)	1 (0.67%)	5 (3.36%)	6 (1.34%)
Number of Patients by Sex/Gender				
Male	55 (36.9%)	52 (34.9%)	49 (32.9%)	156 (34.9%)
Female	94 (63.1%)	97 (65.1%)	100 (67.1%)	291 (65.1%)
Number of Patients by Insurance Status				
Medicare Only	126 (84.6%)	130 (87.2%)	136 (91.3%)	392 (81.7%)
Medicare and Medicaid	21 (14.1%)	19 (12.8%)	11 (7.38%)	51 (11.4%)
Other	2 (1.34%)	0 (0.00%)	2 (1.34%)	4 (0.89%)
Total	149	149	149	447

*"Other" represents patients who had another dual-eligible insurance that was not Medicare and full Medicaid coverage. Dual-eligible patients are defined as those with both Medicare and Medicaid insurance.

Out of the 447 patients within the MSSP ACO who underwent THA and TKA procedures between the years 2016 and 2018, 81.7% were non-Hispanic White (n=365), and the next largest category, 7.61%, were Black (n=34). Sixty-five percent of the patients in the physician-led MSSP ACO who underwent THA and TKA procedures between the years 2016 and 2018 were women (n=291), while 35% were men (n=156). Most patients in the MSSP ACO who underwent THA and TKA procedures had Medicare insurance only (n=392; 81.7%), but most of the remaining patients had both Medicare and Medicaid insurances (n=51; 11.4%).

Table 3 describes the two different risk stratification scores, categorized by the patient's sex/gender, that were used to establish post-surgical outcomes for the patient population who underwent THA and TKA procedures within the MSSP ACO. CMS calculated one of the risk scores, and the other risk score was calculated using the MSSP ACO's proprietary risk stratification algorithm (PHDS), which was described in the "Methods" section.

Table 3. Risk Scores Stratified by Sex/Gender, 2016 to 2018.

Year	2016	2017	2018	Average
PHDS Risk Score				
Male	18.9	16.8	17.4	17.7
Female	16.1	14.2	16.9	15.7
Average Patient	17.1	15.1	17.1	16.4
CMS RAF Score				
Male	1.4	1.1	1.1	N/A
Female	1.4	0.9	1.0	N/A
Average Patient	1.4	1.0	1.0	N/A

*RAF, Risk-Adjusted Factor. PHDS, Predicting Hyperglycemic Crisis Death. CMS, Centers for Medicare, and Medicaid Services. The Average Patient PHDS Score represents the average PHDS risk score for all the patients undergoing THA and TKA procedures. N/A indicates that the average risk score was not calculated. CMS RAF scores were not averaged because they are reset annually.

Higher CMS RAF scores and PHDS scores indicate that a patient has more complex medical conditions and greater comorbid conditions (i.e., diagnoses, hospital admission, length of stay in days, readmission, ED visits, age, drug, or alcohol abuse, behavioral health). These risk scores are used to adjust the MSSP ACO's health service reimbursement that correlates with a higher level of complexity of care.

As seen in Table 3, there are considerable deviations from the CMS RAF scores and the PHDS risk scores, which is due to the CMS RAF score resetting at the end of every calendar

year. We also see that male patients had a greater PHDS risk stratification score than female patients in 2016, 2017, and 2018. Thus, men had a greater average PHDS risk score over the three years than women (17.7 vs. 15.7). Men had a greater average PHDS risk stratification score than the average patient undergoing THA and TKA procedures in the MSSP ACO (17.7 vs.16.4) (Table 3).

Concerning patients' total costs of care data shown in Table 4, we see that male patients undergoing THA and TKA procedures in the MSSP ACO had a lower average total cost of care than female patients in 2016 and 2017; however, we see that female patients' average total cost of care was lower than those of male patients in 2018.

Table 4. Total Cost of Care for Each Patient Categorized by Sex/Gender, 2016 to 2018.

Year	2016	2017	2018
PBPY ($)			
Male	$17,624	$17,398	$16,626
Female	$18,440	$18,037	$15,051
Average Patient	$18,139	$17,814	$15,569

*PBPY, Per Beneficiary Per Year.

Figure 8 represents a graphical visualization of the average total cost of care data described in Table 4.

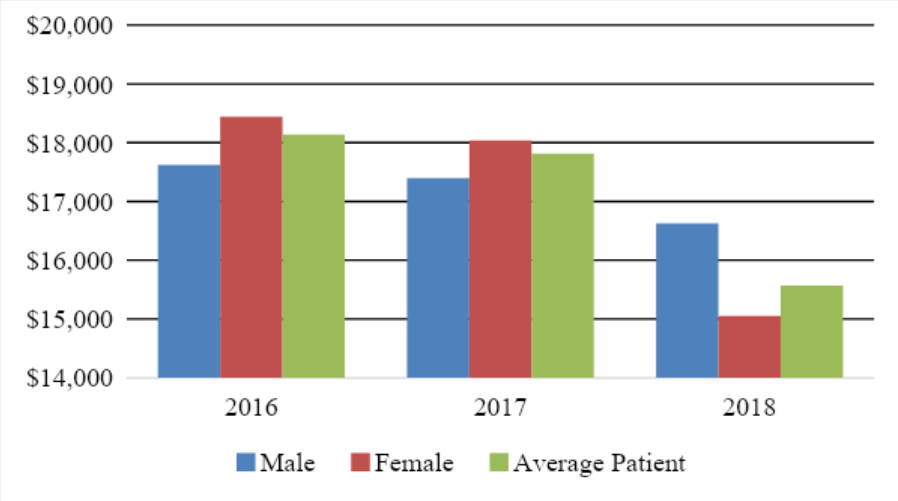

Figure 8. Decreasing Cost to Treat Patients Stratified by Sex/Gender, 2016 to 2018.

The data in Figure 8 show an interesting trend between the years 2016 and 2018. We see that the total costs of care for men, women, and the average patient undergoing THA and TKA procedures in the physician-led MSSP ACO are decreasing over the three years. Specifically, male patients' average total cost of care decreased by 5.66%, female patients' average total cost of care decreased by 18.4%, and the costs associated with treating the average patient in the MSSP ACO who underwent THA and TKA procedures decreased by 14.2% between the years 2016 and 2018.

Table 5 compares the average total cost of care to treat patients with only Medicare insurance undergoing THA and TKA procedures with the average total cost of care to treat dual-eligible patients who received the same orthopedic procedures in the MSSP ACO. As seen in Table 5, the average total cost of care for patients with only Medicare was less than the average total cost of care for dual-eligible patients in all three years (i.e., 2016 - 2018).

Table 5. Total Cost of Care Per Patient Stratified by Insurance Status, 2016 to 2018.

Year	2016	2017	2018
Insurance Type			
Medicare Only	$17,607	$17,503	$15,587
Medicare and Medicaid	$19,890	$19,944	$15,777

*Dual-eligible patients are defined as those with both Medicare and Medicaid insurance.

Figure 9 represents a graphical visualization of the average total cost of care to treat Medicare-only patients and dual-eligible patients described in Table 5.

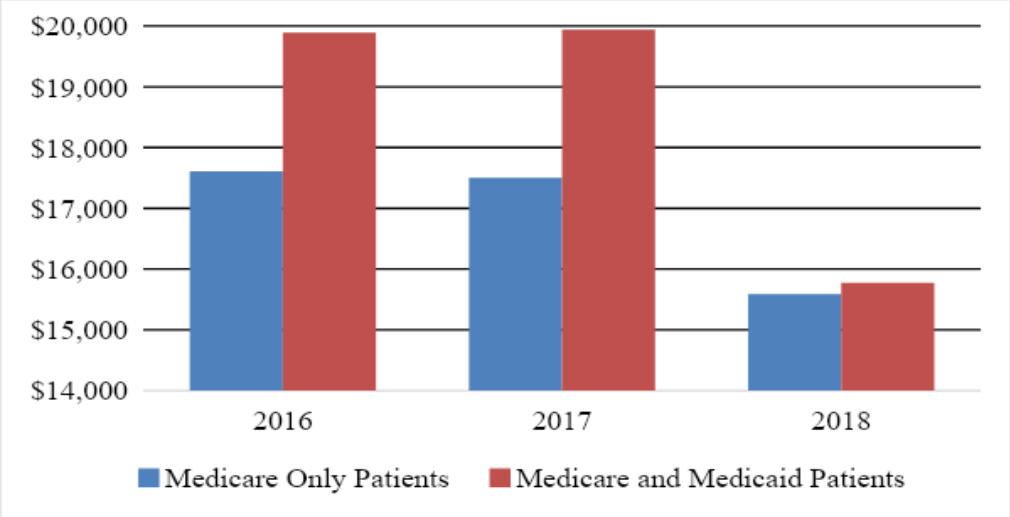

Figure 9. Decreasing Cost to Treat Patients Stratified by Insurance Status, 2016 to 2018.

The same trend mentioned in Figure 8 is seen in Figure 9. We see that the average total costs of care for patients with only Medicare insurance and dual-eligible patients who received THA and TKA procedures in the MSSP ACO are decreasing between the years 2016 and 2018. Over these three years, Medicare-only patients' average total cost of care decreased by 11.47%, and dual-

eligible patients' average total cost of care decreased by 20.7%. Figure 9 also shows that the total cost of care for Medicare-only patients and dual-eligible patients remains stagnant between 2016 and 2017 but drops significantly in 2018. This cost-trend between 2016 and 2018 could be an indicator of 1) the MSSP's maturation as CMS has refined its performance measures and the program's technical components, and 2) MSSP ACOs are learning how to succeed under these arrangements and are consequently developing better healthcare delivery practices. However, the data from the present study cannot explain why this trend occurred within the three years; thus, I can only speculate why this trend occurred. Interestingly, CMS data on total earned shared savings from all MSSP ACOs in the U.S. indicate a trend like the one seen in Figure 9. The total earned shared savings from all MSSP ACOs were $700 million in 2016, rose to $799 million in 2017, and jumped to $983 million in 2018 (Centers for Medicare and Medicaid Services, 2020).

CHAPTER 4: DISCUSSION

The purpose of this study was to determine whether there were any sex/gender-specific differences in postoperative outcomes between male and female patients who underwent total hip arthroplasty (THA) and total knee arthroplasty (TKA) procedures in a physician-led Accountable Care Organization (ACO) participating in the Medicare Shared Savings Program (MSSP) located in the western U.S. over three years (2016 to 2018).

The present study only analyzed patients who received procedures coded with DRG codes 468, 469, and 470, which represent THA and TKA procedures. To clarify, this study did not analyze all the patients within the physician-led MSSP ACO, but only looked at patients within the MSSP ACO who underwent THA and TKA procedures. Thus, this study cannot form any conclusions about all the patients within this MSSP ACO, but it can form conclusions about the sub-sample of patients (n=447) who underwent THA and TKA procedures.

SAMPLE POPULATION DEMOGRAPHICS

Patients undergoing THA and TKA procedures in the MSSP ACO between the years 2016 and 2018 were segmented into categories based on their race/ethnicity, sex/gender, and insurance status. Dividing the demographic data into multiple categories provided a more in-depth analysis of the composition of these patients.

According to my findings, the demographic data of the sample patient population indicate that most of the MSSP ACO patients who underwent THA and TKA procedures were non-Hispanic White (81.7%) and had only Medicare insurance (81.7%). Singh et al. (2014) found that the standardized utilization rates for both primary and revision THA and TKA procedures were significantly lower for Blacks than non-Hispanic Whites, as well as Epstein et al. (2014),

who observed that MSSP ACO patients are less likely to be Black or eligible for Medicaid and had higher incomes than non-ACO patients. It is important to note that the findings from this study cannot be generalized to all patients within an MSSP ACO or all patients undergoing THA and TKA procedures. This study only examined patients who underwent THA and TKA procedures within an MSSP ACO. CMS data on the MSSP show that 82% of all MSSP ACO beneficiaries in the U.S. have only Medicare insurance, which is like the population of Medicare-only patients who underwent THA and TKA procedures in this MSSP ACO (Centers for Medicare and Medicaid Services, 2020). However, the CMS data also indicate that 17% (11%-disabled; 6%-aged dual) of all MSSP ACO beneficiaries are dual-eligible patients, which is slightly greater than the population of dual-eligible patients who underwent these two procedures in this MSSP ACO. It is important to note that the study's findings cannot be generalized to all MSSP ACOs because this study only examined patients who underwent THA and TKA procedures within one MSSP ACO.

Patients' race and sex/gender did not reflect the population demographics of the area where this physician-led MSSP ACO is located. Patients who underwent THA and TKA procedures and were part of this MSSP ACO were more likely to be non-Hispanic White and less likely to be Hispanic and Asian than the geographical area where it is located. However, the number of patients who were Black is similar to the MSSP ACO's geographical area. The patients in this MSSP ACO may explain the differences between the demographics of the patients who underwent THA and TKA procedures in this sample and the population demographics. The MSSP ACO patient study population may not be representative of the general population; however, I do not have data on the entire set of patients in this MSSP ACO.

In short, this MSSP ACO could be attracting patients with a certain income, sex/gender, and race (Epstein et al., 2014).

My findings also indicate that patients who underwent THA and TKA procedures in the MSSP ACO were predominantly female (Table 2). A study conducted by Epstein et al. (2014) reported that more than half of the patients in MSSP ACOs are women (58.8%). However, because the data in the present study only analyzed the subpopulation of patients in the MSSP ACO who underwent THA and TKA procedures, my findings cannot be generalized to all patients in the MSSP ACO. A potential reason why there may be more female patients who underwent THA and TKA procedures in the MSSP ACO than male patients is that most Medicare beneficiaries are women (Owens, 2008). There could also be more female patients undergoing THA and TKA procedures because there are just more of them (Duffin, 2019). The percentage within males undergoing THA and TKA procedures in the physician-led MSSP ACO could also be lower than the percentage within females who received these orthopedic procedures.

Studies have also found that women visit physicians for hip and knee musculoskeletal (MSK) disorders more often than men and are also more likely to undergo total joint arthroplasty procedures than men (Maradit et al., 2014; Mota et al., 2012; Katz et al., 1996). Thus, another potential reason why there may be more women than men undergoing THA and TKA procedures in the MSSP ACO is that these women are experiencing greater and more severe MSK disorders, which may cause them to seek more of these procedures than men. However, the data in the present study do not allow me to make any conclusions about whether women generally experience more severe MSK disorders than men. Also, the number of patients who were part of

the MSSP ACO and received THA and TKA procedures was less likely to be male and more likely to be female than the geographical area where the MSSP ACO is located.

My findings also conflict with other researchers' findings. Studies have reported that physicians, specifically orthopedic surgeons, are more likely to recommend total joint arthroplasty procedures to male patients than female patients (Al-Taiar et al., 2013; Hame & Alexander, 2013; Hawker et al., 2000; Novicoff & Saleh, 2011). The present study does not provide the total number of male and female patients that visited the treatment-recommending MSSP ACO physicians. Therefore, I could not determine whether men had a greater likelihood than women to be recommended for THA and TKA procedures. Other studies have found that physicians refer women less often than men for specialty care (Borkhoff et al., 2008; Franks & Clancy, 1997).

Even though my data indicate that female patients undergo more THA and TKA procedures than male patients in an MSSP ACO, the higher rate of utilization of these surgical procedures does not consider the higher rate of prevalence of MSK disorders in women. According to Hawker (2000), 44.9 per 1,000 women, and 20.8 per 1,000 men have a potential need for total joint arthroplasty in the U.S. However, when these researchers considered patients who were willing to undergo total joint arthroplasty, the number of surgical candidates decreased to 5.3 per 1,000 women and 1.6 per 1,000 men. While their data indicate high underuse of total joint arthroplasty for both men and women, the underuse is three times higher in women than in men (O'Connor, 2006; Novicoff & Saleh, 2011). Judge et al. (2010) also found that men are more likely to receive greater provision of THA and TKA services relative to their needs when compared to women. To clarify, the study only analyzed patients undergoing THA and TKA

procedures who were part of an MSSP ACO. Thus, the findings from this study cannot be generalized to all women and men.

PHDS RISK STRATIFICATION SCORE

Turning to the Predicting Hyperglycemic Crisis Death (PHDS) risk stratification scores shown in Table 3, male patients had higher PHDS scores compared to female patients for all years analyzed (2016-2018). However, it is important to note that my study was not able to provide a PHDS risk stratification score before the THA and TKA procedures were performed on the MSSP ACO patients. Having a patient's PHDS risk stratification score pre-surgery would have allowed me to analyze if the surgical intervention improved the patient's degree of health. Lim et al. (2015) found that TKA surgery improved male and female patients' functional status. Also, having a pre-operative PHDS score would have allowed me to analyze whether male or female patients are sicker at the time of receiving THA and TKA procedures. Endo et al. (2014) found that men were more likely to have a greater American Society of Anesthesiologists (ASA) rating than women, indicating that men have more severe medical comorbidities than women at the time of THA surgery. However, Lim et al. (2015) found that women had poorer preoperative knee flexion compared to men. Future research is recommended to see whether there are sex/gender-specific differences in pre-operative status for THA and TKA procedures between male and female patients. Due to the lack of available data, the present study fails to analyze whether male or female patients are sicker before receiving THA and TKA procedures and whether these surgical interventions improved patients' overall health and well-being.

As mentioned previously in the "Methods" section, the variables used to calculate the PHDS score were diagnoses, hospital admissions, length of stay in days, readmissions, ED visits,

age, drug or alcohol abuse, and behavioral health. Thus, a higher PHDS risk score suggests that male patients undergoing THA and TKA procedures are more unhealthy and have worse postoperative outcomes than that of female patients undergoing the same orthopedic procedures. Also, a higher PHDS risk score may indicate that male patients who have undergone THA and TKA procedures are at an increased risk of rehospitalization. However, because I do not know exactly how each variable was weighted in the PHDS algorithm, I can only speculate on which variables may have caused the higher PHDS score in men. Other studies in the literature support the finding that men have worse outcomes than women after receiving THA and TKA procedures.

According to a study presented at the 2015 Annual Meeting of the American Academy of Orthopaedic Surgeons (AAOS), women fare better than men following THA and TKA procedures. The researchers found that following surgery, men were 15% more likely to return to the ED within 30 days of hospital discharge following either THA or TKA procedures, 60% and 70% more likely to have an acute myocardial infarction (heart attack) within three months following THA and TKA procedures, respectively, 50% more likely to require a revision arthroplasty within two years of receiving TKA procedures, and 25% more likely to be readmitted to the hospital and 70% more likely to experience an infection or revision surgery within two years of receiving TKA procedures, compared to women (Ravi et al., 2015). Lim et al. (2015) found that women record greater improvements in pain and physical activity after undergoing TKA procedures. Also, the American Academy of Orthopaedic Surgeons (2019) has accepted as fact that male patients who sustain hip fractures have more comorbidities and higher mortalities than female patients with hip fractures. The American Academy of Orthopedic Surgeons has also reported that males who sustain hip fractures are more likely to sustain a

secondary hip fracture and experience severe disability than female patients with hip fractures (American Academy of Orthopaedic Surgeons, 2019).

Liebs et al. (2011) also established that women record better pain, physical function, and stiffness scores in the short-term after receiving TKA procedures than men. Endo et al. (2004) found that male patients were more likely to sustain medical complications (i.e., postoperative pneumonia, arrhythmia, delirium, and pulmonary embolism) and had greater mortality rates one year after receiving THA procedures than that of female patients. Other studies have also observed that male hip fracture patients are sicker than female patients after receiving THA procedures (White et al., 1987; Diamond et al., 1997; Fisher et al., 1991). Singh et al. (2013) conducted a risk-adjusted analysis of post-TKA procedure complications from a sample of elective primary TKA cases. These researchers found that compared to women, men had 48% higher adjusted odds of one-year mortality after undergoing primary TKA procedures. Also, they found that male patients were 31% more likely to develop surgical wound infections, 25% more likely to be readmitted to the hospital within 30 days of receiving TKA procedures, and 20% more likely to receive revision surgeries five years after receiving TKA procedures than that of female patients. Heck et al. (1998) also found that male gender was a significant factor that increased the likelihood of surgical revision within two years of receiving primary TKA procedures.

However, my findings are not supported by other studies in the literature. Novicoff & Saleh (2011) found that functional improvement after receiving total joint arthroplasty procedures is comparable between male and female patients. Also, Mehta et al. (2015) did not find any difference in the long-term post-treatment outcomes between men and women after

undergoing TKA procedures. Lastly, Rolfson et al. (2009) observed that following THA procedures, treatment outcomes were similar between men and women.

COST TO TREAT BENEFICIARIES

Looking at the total cost of care data shown in Table 4, we see that female patients undergoing THA and TKA procedures were more costly to treat than male patients in the years 2016 and 2017. This finding seems to go against common intuition. As previously mentioned, my results indicated that men who underwent THA and TKA procedures were more ill than women undergoing these same procedures in the MSSP ACO. Thus, one would expect that a sicker patient is a more costly patient. However, my findings seem to indicate the opposite; that is, female patients who underwent THA and TKA procedures in the MSSP ACO are more expensive to treat than male patients receiving these same procedures. The higher total costs of care and lower PHDS scores for women undergoing THA and TKA procedures than men may be explained by the fact that women are seeking more health services than men. Women being more proactive in seeking health care services could make them healthier than their male counterparts. In health care, women often are the primary decision-makers regarding selecting the source of care (Berkowitz, 2019). A 2008 American Academy of Family Physicians national survey found that 90% of women were responsible for health care decision-making for themselves and their family members. Also, women with children under the age of 18 are more likely than their husbands to select their child's physician, take their child to doctor's appointments, ensure their children receive recommended care, and make decisions about their children's health insurance (Salganicoff et al., 2005). Increasingly, women want to play a strong role in their health care decisions (Arora & McHorney, 2000). Earlier findings that women are significant contributors to total medical costs have been cited in many studies.

A study conducted by Hawker et al. (2000) concluded that although both men and women underutilize arthroplasty, the underuse in women imposes a larger financial burden on the government, insurance companies, individuals, and society than men. These researchers explain that underutilization of arthroplasty in women exacerbates their musculoskeletal (MSK) conditions; thus, needing more treatment later. Gupta et al. (2005) found that women are more likely to report costs associated with osteoarthritis than men, especially women in rural areas.

Bertakis (2000) found that women had greater medical costs for primary care, specialty care, emergency treatment, diagnostic services, and total annual charges compared to men. Interestingly, she also found that there was no statistically significant difference in the number of hospitalizations or hospital charges between male and female patients. An analysis of an integrated database containing information on medical and pharmacy claims revealed that women contributed to 60% of medical spending and consumed 59% of the prescription volume (McNamara, 2001). Data from the Medical Expenditure Panel Survey (MEPS) between 1999 and 2001 showed that among privately insured seniors, women spent 17% more per person per year on prescription drugs than men ($1,178 vs. $1,009) (Correa-De-Araujo et al., 2005).

Woolhandler & Himmelstein's (2007) analysis of the 2003 MEPS data showed that in the adult population aged 18-64 years, the medical spending per patient was $847 for men and $1,844 for women. McNamara (2001) report that women's reproductive health encompasses 16% of overall health plan costs, which is more than cardiovascular disease, diabetes, and asthma combined; thus, female patients may be more expensive to treat because women may require reproductive care. Bertakis (2000) found that women visited their primary care providers and used more diagnostic services than men; thus, women may be more costly because they utilize more physician services. Muller (1990) observed that women have more episodes of acute

illness and need more long-term care over their longer lifespans than men, which could potentially explain why women have greater total costs of care compared to men.

Another plausible explanation for the higher total cost of care for female patients is that women have lower social support than men (Demiralp et al. 2019). It is important to note that the data in the present study do not indicate that women have lower social support than men; this is just pure speculation on why women undergoing THA and TKA procedures in the physician-led MSSP ACO have greater total costs of care than men. This lower social support could add other additional health care expenses; female patients would not only have to pay the direct cost of their surgery but must hire caregiving services to carry out household roles during recovery from surgery. With this understanding of the costs of surgery, women may incur higher costs to undergo THA and TKA procedures, even if the direct costs of operation are standard for both male and female patients. However, the present study could not separate indirect costs from the direct costs for patients undergoing THA and TKA procedures in the MSSP ACO. Thus, the present study cannot form any conclusions on whether female patients have greater indirect costs from surgery than men in the MSSP ACO. Future research is recommended to see if the cost associated with caregiving services could cause sex/gender-specific differences in patients' total costs of care.

It is important to note that in 2018, female patients undergoing THA and TKA procedures became less costly to treat than male patients (Table 4). A potential explanation for this phenomenon could be that this physician-led MSSP ACO emphasized the management of postmenopausal women. This point was made because the data shown in Table 4 and Figure 8 indicate a greater drop in female patients' total cost of care than that of male patients (18.4% vs. 5.66%).

In addition to quantitatively depicting the difference in costs between male and female patients undergoing THA and TKA procedures, the data shown in Table 4 and Figure 4 show a trend of decreasing total cost of care to treat each patient in the MSSP ACO. As mentioned in the "Results" section, between 2016 and 2018, male patients' total costs of care decreased by 5.66%, female patients' total costs of care decreased by 18.4%, and the cost associated with treating the average patient in the MSSP ACO decreased by 14.2%. This trend is also seen when patients were categorized by insurance status (i.e., Medicare-only patients vs. dual-eligible patients). Specifically, between 2016 and 2018, Medicare-only patients' total costs of care decreased by 11.47%, and dual-eligible patients' total costs of care decreased by 20.7%.

These significant decreases in the total cost of care for patients provide key evidence that shows that this physician-led MSSP ACO located in the western U.S. is fulfilling its role as a health cost-reducer. To reduce patients' total costs of care, this physician-led MSSP ACO adopted a significant patient coordinated care system that required the MSSP ACO medical director or nurse case managers to monitor, among multiple factors, hospital bed days, optimized use of post-operative skilled nursing facilities (SNFs), and aggressive management of patients' comorbid conditions.

According to the Centers for Medicare and Medicaid Services 2019 Care Coordination Toolkit, MSSP ACOs have been collaborating with SNFs to provide their beneficiaries with efficient, proper post-acute care. To support care-coordination efforts with SNFs, MSSP ACOs have established networks of high-performing SNFs, engaged SNFs in care-coordination processes, and have identified staff to support beneficiaries' care transitions to SNF (Centers for Medicare and Medicaid Services, 2019a).

Other strategies have been cited in the literature that MSSP ACOs use to better transition to value-based care. According to Kraus (2019), the top twenty MSSP ACOs have adopted three main strategies to lower Medicare spending and improve patient care quality. These shared practices include encouraging patients to be more active in their care, helping chronically ill patients better manage complex conditions, and reducing avoidable hospitalizations. To support patient decision-making, an MSSP ACO developed an SNF scorecard (Appendix 3). As seen in Appendix 3, this scorecard provides MSSP ACO beneficiaries with information on SNF performance on measurable outcomes (i.e., preventing rehospitalization, improving patient independence, and reducing length of stay)

Research analyzing the cost-savings of MSSP ACOs and publicly published data seems to corroborate my findings. Studies report that overall, the MSSP has reduced spending and improved quality of care compared to FFS Medicare (Department of Health and Human Services, 2017; McWilliams et al., 2018). Other studies have found that compared to non-ACOs, the MSSP ACO model is associated with reduced post-acute care and SNF stays (McWilliams et al., 2017), reduced admissions (Winblad et al., 2017), and improved patient experiences (McWilliams et al., 2014). According to CipherHealth.com (2019), from the Medicare Shared Savings Program (MSSP) alone, 60% of participating MSSP ACOs have generated over $1 billion in savings for CMS. After sharing the savings back with the MSSP ACOs, CMS saved $313.7 million in savings. Also, Epstein et al. (2014) found that patients who were part of an MSSP ACO had 5.8% lower total costs of care than patients who were not part of an MSSP ACO ($7,694 vs. $8,164). Multidisciplinary health care teams that coordinate care and monitor patient recovery, like MSSP ACOs, may improve patient satisfaction, improve efficiencies, and reduce readmissions (Barbieri et al., 2009; Burnham et al., 2017; McLawhorn et al., 2017).

Lastly, Parasrampuria et al. (2018) found that MSSP ACOs are a mechanism for decreasing costs by improving the quality of care.

Even though there is evidence that MSSP ACOs do reduce the total cost of care for their beneficiaries, Markovitz et al. (2019) concluded that MSSP ACOs do not decrease costs or improve the quality of patient care. One possible explanation is that MSSP ACO's do not have the ability to prohibit out-of-network care, which limits their control over spending (Lin et al., 2020). Additional studies need to be conducted to analyze whether MSSP ACOs are true health cost reducers. Reducing healthcare costs is of utmost importance. Growth in medical spending has caused stagnant wage growth for many people and is squeezing public and private resources that could be devoted to other priorities such as education and infrastructure (Altman & Mechanic, 2018).

Also, the data shown in Table 5 indicate that patients with only Medicare insurance have lower total costs of care than dual-eligible patients over the period between 2016 and 2018. Data from the Kaiser Foundation Commission on Medicaid Facts (2011) indicate that Medicare and Medicaid spending averaged $20,000 per dual-eligible patient, which was about five times greater than spending on other Medicare beneficiaries. Also, Cylus et al. (2011) observed that patients 65 years or older with Medicare insurance had lower health expenditures than those with Medicaid insurance. It is important to note that the patients who only have Medicare insurance have a 20% co-insurance payment that they are responsible for paying while dual-eligible patients do not have the 20% co-insurance payment. Dual-eligible patients do not have any out-of-pocket expenses when they utilize medical services. Specifically, Medicaid pays their Medicare Part B premiums (Medicare Part B premiums were $96.40for most beneficiaries in 2010), pays their out-of-pocket payments charged for many Medicare services, and covers

critical benefits Medicare does not cover, such as long-term care, dental care, and eyeglasses (Kaiser Commission on Medicaid and the Uninsured, 2011). Thus, the total cost of care for Medicare-only patients may be lower than that of dual-eligible patients because Medicare-only patients are foregoing health services because of their associated out-of-pocket expenses. However, this study cannot deduce whether Medicare-only patients are foregoing health services. Claxton et al. (2019) have shown that high health care costs can be a barrier for patients to access care in the U.S. Their survey data indicated that about 1 in 10 adults report having delayed foregoing any medical care because of its cost. Also, Ackerman, Livingston, & Osborne (2016) observed that patients did not undergo THA and TKA procedures due to cost barriers.

Dual-eligible patients' higher level of health care spending could also reflect their greater health needs and utilization of services compared to patients with only Medicare insurance. Dual-eligible patients represent low-income seniors and younger people with disabilities (Appendix 4). They are among the sickest and poorest patients covered by either Medicare or Medicaid programs (Kaiser Commission on Medicaid and the Uninsured, 2011). Recent estimates show that dual-eligible patients account for a disproportionate portion of spending in both Medicare and Medicaid (Rousseau et al., 2010). In 2005, dual-eligible patients' combined Medicare and Medicaid spending totaled nearly $200 billion (Kaiser Commission on Medicaid and the Uninsured, 2011). The Kaiser Commission on Medicaid and the Uninsured (2011) found that most dual-eligible patients have very low-incomes: 55% of them have an annual income below $10,000 compared to 6% of all other Medicare beneficiaries (Appendix 5). Also, dual-eligible patients have more substantial physical and mental health needs, more likely to have attained less than a high school education, more likely to be a member of a racial or ethnic

minority, have a greater tendency of living in nursing homes compared to other Medicare beneficiaries (Kaiser Commission on Medicaid and the Uninsured, 2011) (Appendix 5). Dual-eligible patients are also more likely never to have been married (Coughlin, Waidmann, & Phadera, 2012). Because dual-eligible patients have significant medical needs, they may have much higher per capita costs than patients with only Medicare insurance. Previous studies have also shown that dual-eligible patients differ from Medicare-only patients in many ways.

In summary, the present study shows that 1) male patients have worse postoperative outcomes after undergoing THA and TKA procedures than female patients, 2) female patients undergoing THA and TKA procedures have greater total health care costs than that of male patients receiving the same surgical interventions, and 3) this physician-led MSSP ACO has been successful in decreasing the total cost of care for its patients undergoing THA and TKA procedures. Since this MSSP ACO has demonstrated significant cost-reductions for female patients undergoing THA and TKA procedures in a three-year period, female patients undergoing these two procedures may be prime targets for healthcare organizations looking to reduce health care costs. Also, because male patients undergoing THA and TKA procedures were found to be more unhealthy than female patients, male patients undergoing these orthopedic procedures may be a critical population for healthcare organizations to focus on to improve post-surgical outcomes. This will be of importance as the health care reimbursement system shifts from an FFS model to a value-based model.

CHAPTER 5: CONCLUSION

The present study's results have implications from a clinical perspective as well as from an economic standpoint. The knowledge that men are more ill and have a greater likelihood of developing unintended outcomes after receiving total hip arthroplasty (THA) and total knee arthroplasty (TKA) procedures identifies a subpopulation of THA and TKA patients who may benefit from closer monitoring during the perioperative period. This will become particularly important as the number of THA and TKA patients continues to escalate, and as increased pressure is placed on healthcare organizations and systems to contain health costs in all aspects of the healthcare arena.

The present study also found that there were deviations in the total costs of care for patients undergoing THA and TKA procedures in an MSSP ACO depending on their sex/gender and insurance types. I observed that female patients undergoing THA and TKA procedures had greater total costs of care than male patients undergoing the same procedures between the years 2016 and 2017; however, in 2018, female patients were found to be less costly than male patients. The data from the present study also indicated that Medicare-only patients were less costly to treat than dual-eligible patients. Thus, the present study has possibly highlighted two subpopulations of patients undergoing THA and TKA procedures that are high-cost patients.

Managing the care of these high-cost patients is a key concern of physicians and health systems that are forming MSSP ACOs, where reimbursement is tied to performance on cost reductions and quality measures (Yongkang et al., 2020). It is recommended that MSSP ACOs adopt high-risk care management programs, which involve coordinating additional resources and health services toward high-cost patients (Powers & Chaguturu, 2016). Care management programs adopted by MSSP ACOs have taken many different forms and are aimed to target

specific populations of patients. The following section will discuss two care management programs that have been implemented by MSSP ACOs.

CARE MANAGEMENT PROGRAM: EXAMPLE #1

Multiple MSSP ACOs in the U.S. have focused on ways to encourage care coordination in the ED. One strategy MSSP ACOs have developed to meet this goal is to plant care managers within the ED to provide their beneficiaries with timely coordination (Centers for Medicare and Medicaid Services, 2019a). These MSSP ACOs rely on these embedded care managers to drive collaboration between ED clinicians and primary care providers (Centers for Medicare and Medicaid Services, 2019a). These embedded care managers have access to patient information detailing their previous health needs from the electronic health record (EHR) and share this critical information with ED clinicians. Embedded care managers are also able to assist with patient discharges and transfer from the ED to another care setting or the patient's home (Centers for Medicare and Medicaid Services, 2019a).

CARE MANAGEMENT PROGRAM: EXAMPLE #2

An MSSP ACO in the U.S. developed a care management program designed to reduce admissions among its beneficiaries with chronic respiratory cardiac conditions. In this care management program, the MSSP ACO's inpatient care manager communicates with an ambulance service partner, who sends staff to the beneficiary's home within a day of discharge from the hospital to conduct a home safety evaluation. The MSSP ACO staff checks if these beneficiaries have filled their prescriptions, have nebulizers and other equipment necessary to manage their present condition. The staff also checks if the beneficiary understands his/her post-discharge instructions. The MSSP ACO will also send its respiratory therapist to visit the

beneficiary in their homes to talk to them about ways to effectively self-manage his/her condition. The therapist also confirms that the beneficiaries are receiving ongoing care from a primary care physician or pulmonologist, have an emergency medicine pack in their homes, and know about a dedicated telephone number that the MSSP ACO operates for beneficiaries with chronic pulmonary obstructive disorder (COPD). If beneficiaries call this number, they will be connected to MSSP ACO staff that will assess their needs and connect them to a population health coach, a primary care physician, or the ED if there is a true emergency (Centers for Medicare and Medicaid Services, 2019a).

The adoption of high-risk care management programs could substantially reduce costs and improve patients' quality of care. According to the Centers for Healthcare Strategies (2007), care management is a promising team-based, patient-centered approach "designed to assist patients and their support systems in managing medical conditions more effectively." However, because high-risk patients in an MSSP ACO can be a heterogeneous subpopulation, a one-size-fits-all approach may not be effective in decreasing total costs of care and improving the quality of care. Thus, a diversified approach tailored to the clinical realities of target populations is needed for MSSP ACOs to manage the care of their high-cost subgroups. There are implications for health systems, payers, and physicians.

Health systems, no matter their experience levels with alternative payment models, who are assuming responsibility for new patient populations, will require a thorough knowledge of the clinical characteristics and care-utilization patterns of their high-risk subgroups and the identification of evidence-based programs for managing their care. Because there will be a need for large up-front investments to identify high-risk groups and evidence-based programs, payers need to understand that demonstrated proficiency in caring for specific high-risk populations by

an MSSP ACO does not remove the need for contracts to provide adequate financial incentives to support investments in new care-management capabilities. Physicians in MSSP ACOs also have a critical role in engaging their patients and matching them with specific evidence-based programs according to their clinical needs. Furthermore, front-line clinicians can assist health care leaders to identify and test new strategies for high cost-patients and provide insights into care needs at a level of granularity that cannot be gleaned from electronic health data.

Lastly, my study showed that this physician-led MSSP ACO located in the western U.S. has been successful at significantly reducing the total cost of care for its patients receiving THA and TKA procedures between the years 2016 and 2018. This finding indicates that MSSP ACOs can be successful at reducing the total cost of care for its patients and show promise in decreasing health care costs and increasing health care quality. Based on the cost-data collected in the present study, it is recommended that MSSP ACOs should be supported and expanded to decrease health care costs. However, MSSP ACO's ability to continue to reduce health costs and improve patients' quality of care is dependent on their survival in the current healthcare marketplace.

To survive in today's value-based healthcare arena, MSSP ACOs need to adopt innovative organizational practices to decrease their spending and realize increased profits. MSSP ACOs may need to control their beneficiaries' use of out-of-network primary care physicians. Lin et al. (2020) found that patients' use of out-of-network primary care was associated with an increase of $10.79 in quarterly total MSSP ACO spending per patient. Thus, MSSP ACOs might realize more savings if its incentives its patients to seek primary care within its network. For example, MSSP ACOs could lower copayments for primary care physicians within their network.

Future policies aimed at helping MSSP ACOs control their level of out-of-network primary care may also help them lower spending and increase revenues. Policies aimed at expanding the MSSP ACO Beneficiary Program, which allows certain MSSP ACOs to pay beneficiaries a financial incentive to receive primary care within their network, could potentially help MSSP ACOs realize more cost savings (Schulz, DeCamp, & Berkowitz, 2015). However, it is important to note that these incentives would need to be balanced with the protection of patient choice, which is a defining feature of MSSP ACOs. Policymakers should also consider providing data on out-of-network care utilizations to MSSP ACOs to help them identify reasons why their beneficiaries are seeking primary care services out of their network. Also, policies could be enacted to provide training and resources to encourage MSSP ACOs to offer telehealth services in line with those covered under the Bipartisan Budget Act of 2018, which allows MSSP ACOs to expand the use of telehealth services (Shwartz, 2018). Increasing telehealth service capabilities could potentially allow MSSP ACOs to decrease the number of their beneficiaries accessing primary care services out of their network.

In December 2018, CMS released its Pathways to Success rule, which completely overhauled the MSSP. The policies outlined in this new rule provide a new direction for the MSSP by redesigning the participation options available under this program to encourage MSSP ACOs to transition into two-sided models, which means MSSP ACOs may share in savings and are also responsible for repaying shared losses (Centers for Medicare and Medicaid Services, 2018a). Why did CMS propose this rule? According to the CMS program data, MSSP ACOs taking on downside risk perform better than those who do not. Specifically, their data showed that MSSP ACOs taking on downside risk showed an average reduction in spending relative to their targets of $96 per beneficiary, compared to $68 for MSSP ACOs that did not take on

downside risk (Verma, 2019). According to CMS (2018), "these policies are designed to increase savings for the Trust Funds and mitigate losses, reduce gaming opportunities, and promote regulatory flexibility and free-market principles. This final rule also provides new tools to support coordination of care across settings and strengthen beneficiary engagement and ensure rigorous benchmarking." Appendix 6 outlines what changes the Pathway to Success rule has finalized for MSSP ACOs.

However, the Pathways to Success rule and its associated provisions affect a healthcare organization's decision to begin or continue participating in an MSSP ACO. I believe that the MSSP could benefit from an adjustment to one of its key components to better support MSSP ACOs: the timing of moving MSSP ACOs into down-sided risk, which means MSSP ACOs are responsible for financial losses with payers if the MSSP ACOs fail to meet their target benchmarks. Bleser et al. (2019) observed that MSSP ACOs taking on downside risk have higher rates of exit from the MSSP. One of the implications of the 2018 Pathways to Success rule is that MSSP ACOs have only one to three years before moving to a two-sided risk model, which is considerably less than the current six years (Appendix 6). Thus, less time for MSSP ACOs to transition to a two-sided risk model could cause them to drop out of the MSSP.

Interestingly, Bleser et al. (2019) also found that the likelihood of MSSP ACOs dropping out of the MSSP decreases after the first three years of joining this government program. This may suggest that MSSP ACOs need at least three years to adjust to the MSSP and begin making changes in their health care delivery practices to accept downside risk. Policymakers may need to increase the amount of time before MSSP ACOs move into a two-sided risk model to better support MSSP ACOs in this value-based healthcare landscape.

Considering the present study's findings, there needs to be an increased focus and emphasis on improving male patients' outcomes after receiving THA and TKA procedures in MSSP ACOs. One way MSSP ACOs can improve their beneficiaries' outcomes after receiving THA and TKA procedures is to dedicate staff to coordinate care with SNFs. According to the Centers for Medicare and Medicaid Services (2019a), MSSP ACOs have designated a team of care managers to work with SNF staff through telephone calls and in-person visits. Once a beneficiary has been admitted to an SNF, care managers work with the SNF staff to streamline the beneficiary's transition to this new SNF setting and enable the beneficiaries to receive timely therapy, which could potentially improve patient outcomes. An MSSP ACO who integrated this strategy stated that "the care manager's involvement is particularly impactful in the first 30 days of the beneficiary's SNF stay because it ensures that the care plan reflects the health needs identified by primary care and inpatient clinicians who have treated the beneficiary in the past" (Centers for Medicare and Medicaid Services, 2019a, pg. 7)

Another strategy to help improve the post-surgical outcomes of male patients undergoing THA and TKA procedures, orthopedic surgeons, hospitals, and multidisciplinary health care teams need to incorporate more technology in their delivery of care. MSSP ACOs can leverage their EHRs to address social determinants of health. According to the Centers for Medicare and Medicaid Service (2019), an MSSP ACO improved its EHR to help them streamline the referral process to community partners. Appendix 6 describes the details of this specific strategy developed by the MSSP ACO. The updated EHR system has the capability of identifying a patient's unmet needs that are related to social determinants of health. The MSSP ACO's care coordinator used this EHR to create a referral to a social worker within the practice. Also, the MSSP ACO's EHR had the ability to generate direct referrals to community partners. Electronic

health data can be used to improve the health statuses of patients undergoing THA and TKA procedures.

Healthcare organizations and providers may also be able to improve their THA and TKA patients' health statuses and reduce unnecessary costs and complications by integrating mobile and web-based technologies into their delivery of (Feng et al., 2018). Sloan et al. (2018) found that the average age for patients undergoing THA has decreased from 66 years to 64 years and decreased from 68 to 66 years for patients undergoing TKA procedures. This decreased average age for patients undergoing these orthopedic procedures may indicate a population of patients who are more physically active and more technologically adept than patients in the past. Also, Anderson & Perrin (2017) found that the adoption of technology and internet usage among the senior citizen population has grown drastically within the past five years. They also found that almost half of the senior citizen population aged 70 to 74 years in the U.S. own smartphones, and 75% use the internet. Among those who were 65 to 69 years of age, nearly 60% own smartphones, and 82% reported using the internet regularly (Anderson & Perrin, 2017). This evidence shows that the patient population may be receptive to healthcare organizations and clinical providers, increasing the amount of technology in their delivery of patient care.

When the delivery of care is coupled with smartphones, web-based, and other mobile communications, patients may have better health outcomes, and the cost of care may be reduced. The methods of communication would allow patients to connect to their care teams (Burnham et al., 2017; Semple & Armstrong, 2017). Also, innovations in electronic information sharing and communications technologies have allowed orthopedic surgeons, hospitals, and multidisciplinary health care teams to better collaborate and share information with THA and TKA patients and

other health care team members across various platforms throughout the patient care continuum (Semple & Armstrong, 2017).

Smartphone capabilities such as texting, photo-taking, and web-based interfaces may enhance patients' transitions of care from the hospital to their homes, allow patients to communicate their symptoms in text and pictures, and may promote patients to be actively engaged in their recovery after receiving surgery (Mosa et al., 2012; Semple & Armstrong, 2017). Also, online patient engagement portals that are accessible via smartphones, internet, or tablets, may reduce health costs by three mechanisms: replacing in-person follow-up visits, providing discharge instructions to patients and their families, and alerting health care teams to complications during the patient's recovery period (Mosa et al., 2012; Semple & Armstrong, 2017). Increasing the amount of technology in the delivery of patient care can also potentially play an important role in maximizing communication between patients and their providers throughout all points of the care continuum by helping prepare patients for surgery, sharing health information during the hospital stay, and conveying real-time updates on medication, pain control, and rehabilitation protocols at key stages during the recovery period (Fingar et al., 2016; Semple & Armstrong, 2017).

Jayakumar et al. (2017) have observed that patients who received total knee and hip arthroplasty procedures and who enrolled in web-based preoperative education and participated in technology-based programs that encourage increased patient communication and engagement from the preoperative stage through the post-discharge phase, had reduced lengths of stays, decreased costs, and reported having better experiences with their care.

Lastly, wearable devices that contain sensors to monitor patients' movements and posture are being promoted by companies to improve patients' rehabilitation following THA and TKA

procedures. However, a review conducted by Bahadori et al., 2018 concluded that there is very little evidence that supports the notion that wearable devices improve patient outcomes following THA and TKA procedures. It is important to note that these researchers also concluded that these wearable devices show promise in improving patient outcomes after receiving THA and TKA procedures, the implementation of these devices is feasible, and that the devices are safe for patient use.

CMS has seen the promise technology can play in reducing patients' length of stay days, decrease their costs, and increase patient satisfaction with their care. CMS has introduced two new codes for physician services to reimburse health care providers for using technology in their delivery of patient care. These new codes will allow CMS to pay separately for two newly defined physicians' services using communication technology: "brief communication technology-based service" (e.g., virtual check-in) and "remote evaluation of recorded video and/or images submitted by an established patient" (Centers for Medicare and Medicaid Services, 2018b). Thus, health care providers can be separately paid for the "brief communication technology-based service" service when their patients check in with their provider via telephone or other telecommunications device to decide whether an office visit or other service is needed. CMS believes that adopting technology in the delivery of patient care would increase not only the efficiency for physicians but also increase convenience for patients. Also, the "remote evaluation of recorded video and/or images submitted by an established patient" service would allow physicians to be paid separately for reviewing patient-transmitted photo or video information to assess whether a visit is needed.

Incorporating more technology into healthcare delivery is also expected to benefit female patients undergoing THA and TKA procedures. The adoption of more technology in patient care

has already shown the potential to improve women's quality and access to medical care. This can be evidenced by Maven Clinic, a telehealth company for women and families. Maven Clinic works with hundreds of providers that are inside and outside of the traditional medical system, including lactation consultants, midwives, family physicians, obstetricians, and pediatricians to provide on-demand 24/7 access to health care providers for their members. To communicate with providers, members can use video chat or direct message healthcare practitioners using the Maven app. Maven Clinic's maternity service is available 24/7 for women couples who have questions about their health and their newborn's health.

Another company that has revolutionized women's health care with its technology is Clarius Mobile Health, which has developed wireless handheld ultrasound scanners that can be accessed from a smartphone. Their ultrasound scanners can deliver high-resolution ultrasound images traditionally only available with bulkier, high-end systems. These portable ultrasounds can benefit women's maternal care, emergency healthcare, biopsies, and regional anesthesia (Powell, 2018). Portable ultrasound technology can be used in communities where there are remote and underfunded clinics to improve patients' access and quality of pregnancy care, preventative treatment, and emergency care.

Artificial intelligence (AI) has also shown promise to advance women's health. Researchers at Lehigh University developed an AI algorithm to identify cervical dysplasia that could replace expensive equipment needed to run tests like Pap smears and HPV tests (Powell, 2018). According to the latest world cancer statistics (Ferlay et al., 2015), cervical cancer is the fourth most common cancer in women globally (528,000 new cases each year) and the second most common in developing areas (445,000 new cases each year). Cervical cancer is also the fourth most lethal cancer in women worldwide (266,000 deaths) and the third cause of cancer-related death in developing countries (230,158 deaths) (Ferlay, 2015), which means that more

than 80% of the global burden occurs in developing areas. To address this epidemic, Lehigh University's AI algorithm can improve access and quality of medical care and decrease health costs for women in low-resource areas.

Furthermore, studies have shown that women from underserved communities do not adequately use mammograms (DeSantis et al., 2017; Berg et al., 2004). For example, African American mammographic screening rates are 19% lower than rates for non-Hispanic White women (Ahmed et al., 2017), and women living in high-poverty areas are 50% less likely than women living in higher-income areas to have received a mammogram in the previous two years (Calo et al., 2016). Considering this problem, two researchers at Drexel University's School of Biomedical Engineering, Science and Health Systems developed iBreastExam, a hand-held, battery-operated tool to detect breast cancer without radiation. The iBreastExam provides results within minutes, through its paired mobile app. The iBreastExam device has reduced costs considerably, to between $1 and $4 per exam, rather than the $20 that a mammogram costs in India (Powell, 2018).

Lastly, mobile phones and mobile health programs can improve women's access to healthcare. Mobile health programs can be used to remind patients of their appointments, provide remote consultations, ease access to health clinics, improve communication with local health workers, and track information during and after pregnancy, such as infant growth. Evans et al. (2012) analyzed the efficacy of a mobile health program called Text4baby, which delivers text messages to underserved pregnant women and new mothers to change their health, health care beliefs, practices, and behaviors to improve clinical outcomes. Evans et al. (2012) randomized participants, who were all pregnant women first presenting are, to enroll in theText4baby program. They surveyed these women before enrolling in Text4baby (baseline) and after enrolling in this program, which was approximately 28 weeks of baby's gestational age(follow-up).

Interestingly, the researchers found a significant effect of Text4baby intervention exposure on increased agreement with the attitude statement "I am prepared to be a new mother" between baseline and follow-up. For those who had attained a high school education or greater, they observed a significantly higher overall agreement to attitudes against alcohol consumption during pregnancy and observed a significant improvement of attitudes toward alcohol consumption from baseline to follow-up. Thus, mobile health programs such as Text4baby may be a promising program to improve the quality of female patients' care.

LIMITATIONS AND FUTURE AREAS OF RESEARCH

This study was subjected to the following limitations. First, my study did not conduct formal statistical analyses to see if there was a true difference in the PHDS risk scores and the average total costs of care between male and female patients undergoing THA and TKA procedures. If statistical analyses on these data were possible in the present study, I would have used the Student's t-test. This statistical method is commonly used by researchers to examine whether there are differences in patients' costs of health care (Zhou et al., 1997). Also, Student's t-test would have allowed me to see if there was a statistically significant difference between the male patients' average PHDS risk stratification score and female patients' average PHDS risk stratification score. Knowing if there was a statistically significant difference between male and female patients' PHDS risk scores and total costs of care would have allowed me to conclude that the differences found in these data were not attributed to sampling error.

Second, I could not determine what variable(s) in the PHDS risk stratification algorithm caused the increased average PHDS risk score in male patients compared to female patients. Because the PHDS risk stratification score algorithm is a proprietary formula used by the MSSP ACO, I did not have access to how each variable was weighted in the algorithm. Therefore, I was unable to see which variable affected the PHDS risk score the most, limiting my ability to

speculate on the potential reasons why men had a greater risk score than women. Future research is recommended to analyze why men are sicker than women after receiving THA and TKA procedures. Do male patients have a greater likelihood of being admitted to the hospital? Does the sex/gender of patients undergoing THA and TKA procedures affect their length of stay days after receiving these procedures? Are there sex/gender-specific differences between men and women in the number of hospital readmissions after receiving THA and TKA procedures? Are there sex/gender differences in the rate of utilization of the ED? Are men or women more susceptible to alcohol abuse and poor mental health?

Third, I did not collect the PHDS risk stratification score at different periods after the MSSP ACO patients underwent THA and TKA procedures. Ideally, I would have collected the patients' PHDS risk stratification scores every month after they received THA and TKA procedures for two years. This data-collection approach would have allowed me to see if there were any changes in the PDHS risk stratification scores after the THA and TKA procedures were performed. For example, these data would have allowed me to see if there was an equilibration of PHDS risk stratification scores between male and female patients. Also, having access to longitudinal PHDS risk stratification data would have allowed me to identify potential predictors of persistent high-risk patients undergoing THA and TKA procedures. Chang et al. (2019) found that urban residence, chronic medical comorbidities, auditory and visual impairment, chronic pain, any cancer diagnosis, and social instability were predictors of patients being persistently high-risk. These researchers also found that after two years, just 14% of the patients enrolled in the Veterans Health Administration (VHA) remained high-risk for hospitalization. Papakostidou et al. (2012) found that women recorded worse scores in the domains of pain and physical activity than men six weeks after receiving TKA procedures, but the scores leveled out

afterward. Other studies have also found that many high-need patients are just temporarily high-risk (Johnson et al., 2015; Wong et al., 2018; Yoon et al., 2018).

Fourth, the sample size in the present study was not representative of the general population. Not only was the sample population not large enough, but it was also located in one region in the western U.S. Thus, my findings may be tainted by geographic and regional isolation. Future studies are recommended to look at multiple MSSP ACOs in different areas of the U.S. to try to create a better representative sample of the general population.

Fifth, as mentioned previously, the present study does not provide the total number of male and female patients that visited the treatment recommending MSSP ACO physicians. Therefore, I could not determine whether a patient's sex/gender affected the rate of MSSP ACO physician's recommending THA and TKA procedures. Studies have found that physicians refer women less often than men for specialty care (Al-Taiar et al., 2013; Borkhoff et al., 2008; Franks & Clancy, 1997; Hame & Alexander, 2013; Hawker et al., 2000; Novicoff & Saleh, 2011). However, these studies do not analyze physician referral patterns in an MSSP ACO setting. Thus, further research is recommended to see if sex/gender affects physicians' referral patterns for THA and TKA procedures in MSSP ACO settings.

The study's findings are timely, significant, and important. The finding that male patients undergoing THA and TKA procedures in an MSSP ACO have an increased risk of developing poor health after surgery identifies a subpopulation of THA and TKA patients who could benefit from closer monitoring during the perioperative period. The knowledge that an MSSP ACO in the western U.S. has been successful in reducing the health costs of its beneficiaries undergoing THA and TKA procedures indicates that MSSP ACOs may have the ability to act as cost reducers. Reducing healthcare costs is of utmost importance. Health care has accounted for a

growing share of the Gross Domestic Product (GDP). According to the Centers for Medicare and Medicaid Services (2019b), the health share of GDP is expected to rise from 17.8% in 2018 to 19.4% of GDP-or nearly one of every five dollars in the economy by 2027 (Appendix 8).

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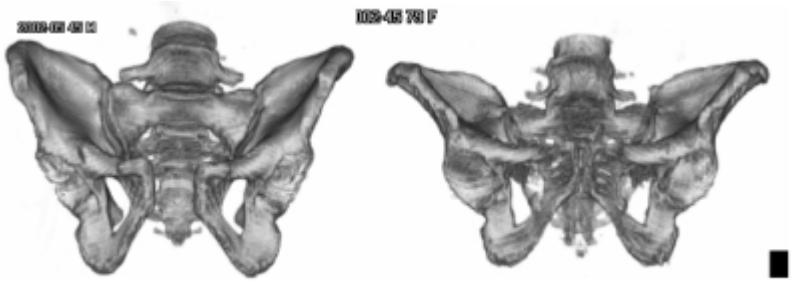
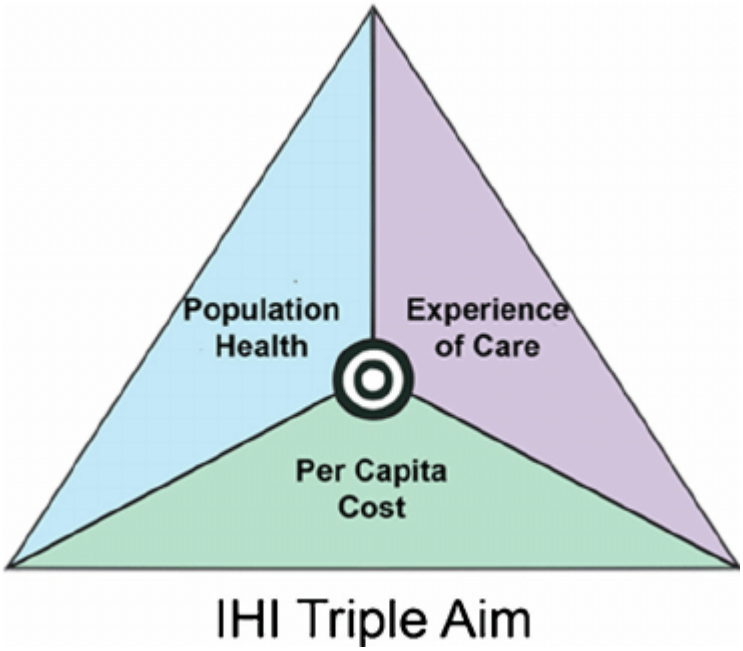
APPENDIX



Male Female

Appendix 1. Representative Male and Female Bony Pelvis (Wang et al., 2004)



Appendix 2. The Institute for Healthcare Improvement's Triple Aim (Institute for Healthcare Improvement, 2020)

Rank*	Facility**	How good are facilities at: Preventing re-hospitalization	Improving patient independence	Cost savings (length of stay)
1	SNF 1 ☺	●●●●	●●●●	●●●●●
1	SNF 1 ☺	●●●●	●●●●	●●●●●
3	SNF 3	●●●	●●●●	●●●●●
4	SNF 4	●●●	●●●●	●●●●
4	SNF 5	●●●●	●●●	●●●●
6	SNF 6	●●	●●●	●●●●●
7	SNF 7	●	●●●	●●●●●
8	SNF 8	●●●●●	●●	●
9	SNF 9	●●●	●●	●
9	SNF 10	●	●●	●●●●●
	SNF 11	These participating facilities aren't ranked because we don't have enough information on their performance yet		
	SNF 12			
	SNF 13			
	SNF 14			
	SNF 15			

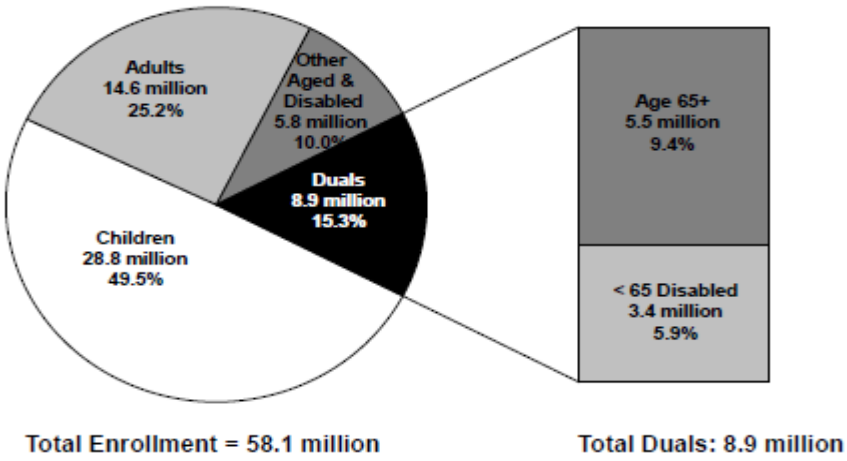
●●●●●	High Performance
●●●●	Better than Expected Performance
●●●	Expected Performance
●●	Worse than Expected Performance
●	Low Performance

Special Designations	
☺	Most recommended by patients

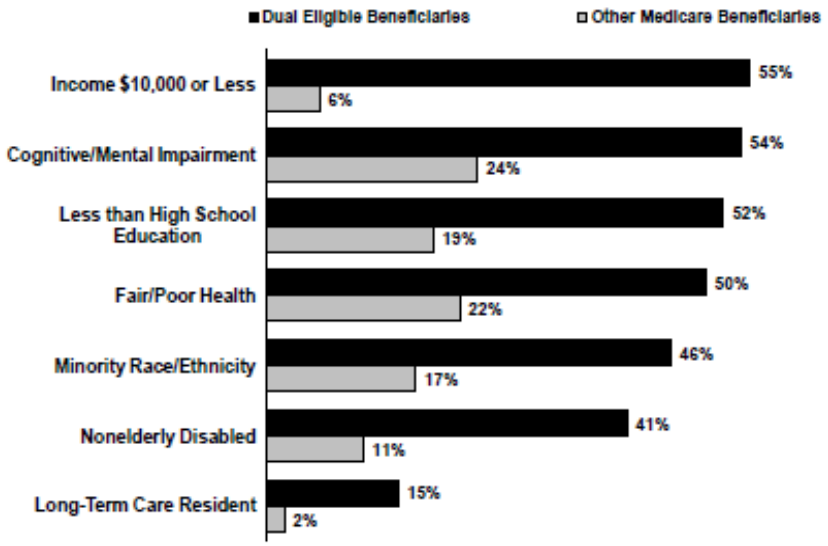
**Medicare patients may choose any Medicare certified skilled nursing facility. The facilities above participate in the Post-Acute Care Program

*Facilities are listed from highest performing to lowest performing based on the total number of circles. In cases of a tie, facilities that rank the same are listed in alphabetical order. Special designations do not impact facility performance or rank.

Appendix 3. An MSSP ACO's Implemented Strategy to Support its Beneficiaries' Decision-Making by Developing an SNF Scorecard. (Centers for Medicare and Medicaid Services, 2019a)



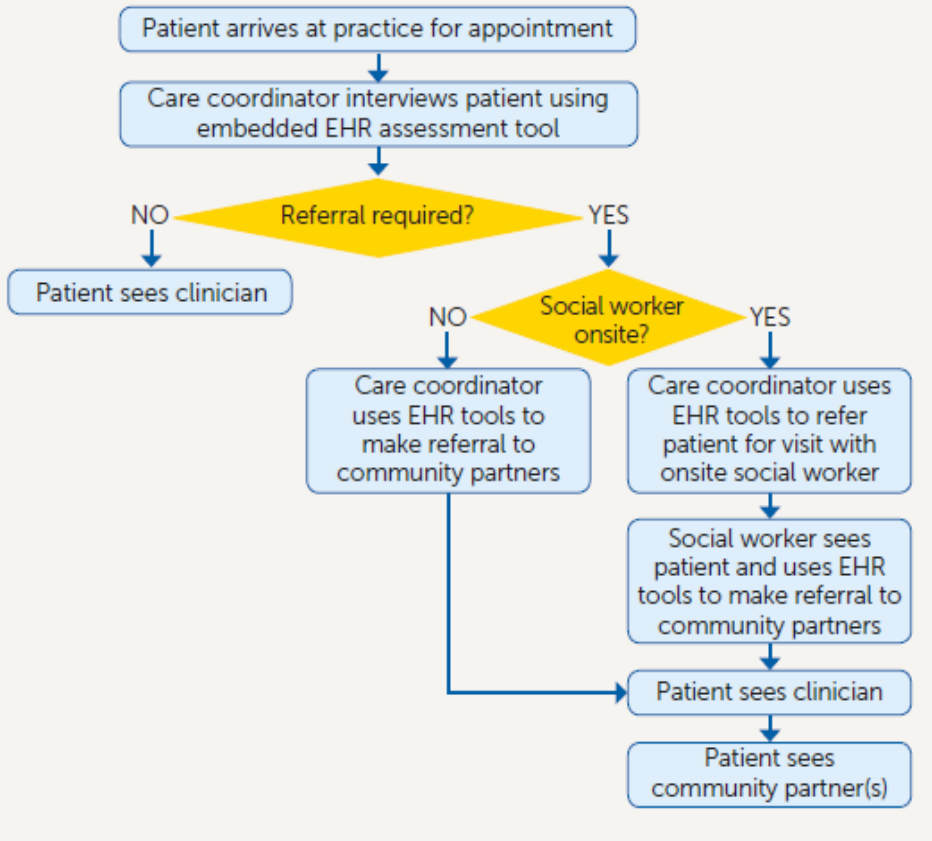
Appendix 4. Dual-Eligible Patient Demographics, 2007 (Kaiser Commission on Medicaid and the Uninsured, 2011)



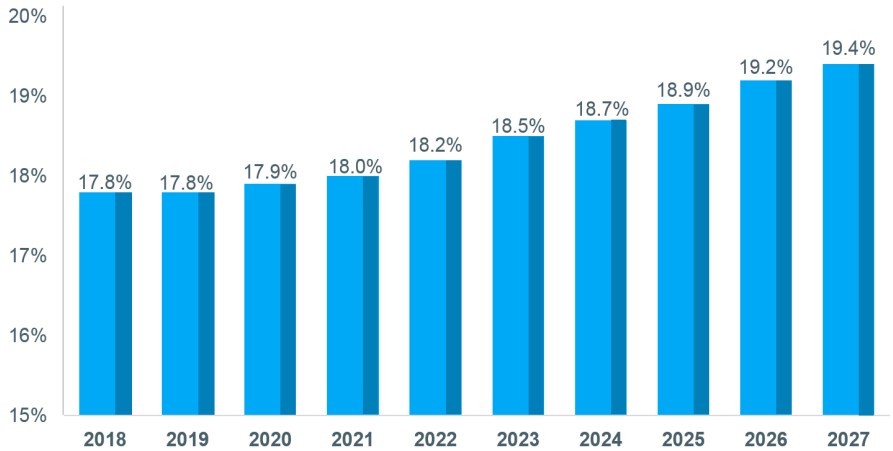
Appendix 5. Comparison of Dual-Eligible Patients and Other Medicare Beneficiaries, 2008 (Kaiser Commission on Medicaid and the Uninsured, 2011)

Appendix 6. CMS's Pathway to Success Rule Changes (Centers for Medicare and Medicaid Services, 2018a)

Category of Change	Rule
Accountability and Competition	"The final rule reduces the amount of time that an ACO can remain in the program without taking accountability for healthcare spending from six years to two years for new ACOs and three years for new "low revenue" (physician-led) ACOs, including some rural ACOs. The rule also strengthens incentives by providing higher shared savings rates as ACOs transition and accept greater levels of risk."
Quality	"To increase flexibility for ACOs taking on risk, Pathways to Success expands access to high-quality telehealth services that are convenient for patients, including telehealth services provided at a patient's place of residence."
Beneficiary Engagement	"Pathways to Success promotes beneficiary engagement and improved health outcomes by allowing ACOs to offer incentive payments to beneficiaries for taking steps to achieve good health, such as obtaining primary care services and necessary follow-up care. In addition, this rule requires ACOs to provide beneficiaries with a written explanation in person or via email or patient portal of what it means to be in an ACO to put patients in the driver seat."
Integrity	"This rule established rigorous benchmarks by incorporating factors from regional Medicare spending to establish an ACO's benchmark during all agreement periods, providing a more accurate point of comparison for evaluating ACO performance. In addition, ACOs that terminate their participation will be accountable for prorated shared losses."



Appendix 7. An MSSP ACO's Implemented Strategy to Leverage its Electronic Health Record to Address Social Determinants of Health (Centers for Medicare and Medicaid Services, 2019a)



Appendix 8. Projected U.S. Healthcare Expenditures as a Percentage of Gross Domestic Product (Patton, 2019)