THE OSTEOARTHRITIS CRISIS IN ALBERTA:
ACCESS, QUALITY, AND LONG-TERM PLANNING

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- every Albertan suffering from osteoarthritis, who live this experience every day of their lives.

"If I have seen further, it is by standing on the shoulders of giants."

- Isaac Newton

Glossary of Terms

Term	Meaning / Definition
90th percentile	The point by which 90% of the people have received service.
AHS	Alberta Health Services.
Arthroplasty	Surgical reconstruction or replacement of a joint.
BJH SCN	Bone and Joint Health Strategic Clinical Network, a provincial network of bone and joint health stakeholders, including professionals, patients, and researchers.
BMI	Body Mass Index.
Median	The mid point (where half of people waiting have received service).
OA	Osteoarthritis.
SCN	Strategic Clinical Network.
SD-OA	System Dynamics OA, a simulation model developed at the University of Calgary that describes how OA patients in Alberta interact with the public health system.
TJA	Total joint arthroplasty.

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Executive Summary

Albertans are waiting an increasingly long time for elective hip and knee arthroplasty. While this intervention is only required by a small fraction of those with osteoarthritis (OA), for those who do require this service, the increased wait has immediate, ongoing and significant impact on their quality of life. Further, as time for surgery increasingly extends beyond the national target of 26 weeks, evidence indicates increased compromising of the opposing joint, thereby accelerating the need for a second surgery. The care required to support those who have OA in various levels of severity, yet are not appropriate for surgery, demands a herculean effort to identify, implement and evaluate evidence informed care pathways.

As Albertans live longer, experience increased rates of obesity and choose arthroplasty as a potential solution, the demand for this procedure continues to increase beyond the rate of population growth alone. Adding to the complexity is the realization that other surgical procedures are falling behind current targets. Together, these factors create a mammoth task for health care providers, planners, administrators and funders.

Alberta has the advantage of previous success in addressing this challenge. A five year plan, partially implemented, resulted in significant, quantified improvements, while simultaneously improving all domains of quality, freed up inpatient bed capacity and created a collaborative province wide approach to quality improvement among service providers serving the hip and knee population. Further, the Alberta Bone and Joint Health Institute has and continues, to project specific volumes that will be required to meet and maintain wait time targets, including the "Four Months in Four Years" as outlined in the current government's election platform.

The Bone and Joint Health Strategic Clinical Network (BJH SCN), along with numerous partners, is working to address the breadth of needs for Albertans with OA. This means refreshing the hip and knee arthroplasty plan to align with new ministerial targets. In addition, the BJH SCN is working to demonstrate, implement and refine a care pathway to support the vast majority of those with OA that require other supports and interventions that exclude surgery. Lastly, the BJH SCN has partnered with researchers and other stakeholders to trial and implement initiatives that prevent injuries and promote healthy lifestyles that may delay the onset of OA symptoms, thereby reducing the eventual demand for surgical and other intensive health resources.

This document outlines the current wait time crisis, provides important context, estimates specific volumes required to achieve and maintain targets and informs readers of emerging initiatives aimed at addressing some of the factors that contribute to Albertans developing OA.

The approach of the BJH SCN and its engaged stakeholders in achieving and maintaining surgical wait time targets, while attending to factors that contribute to the need for surgery, serve as examples that could inform other areas of the health care system.

Access to Care

THE PATIENT EXPERIENCE

Osteoarthritis (OA) is a progressive, chronic condition with no cure. Many risk factors influence the development of OA and how quickly it progresses, including age, body mass index (BMI), genetic factors, and previous traumatic injury.[1-5]

Alberta has some of the richest research available on the experience of patients seeking help with OA and waiting for care.[6-8] This research summarizes the experience in five stages, each with its own challenges: getting medical attention, dealing with the vicious cycle, living a life on-hold, getting through the surgical gate, and reflecting on the quest for help.[6] Even the most well-informed and engaged patients expressed difficulty in accessing care, highlighting challenges with communicating the severity of their symptoms and encountering "locked gates" along their journey. Knowing when to seek help with symptoms and an unwillingness to become a burden to the health care system or their families were commonly described barriers to care. For some marginalized populations, such as the homeless, these barriers were even greater and could appear almost insurmountable.[6; 7]

Many patients expressed the idea that arthroplasty was the "gold standard" of treatment for OA. Until their OA diagnosis had progressed to the point of surgical intervention, they found themselves stuck living a life on-hold, waiting until irreversible damage occurs to their joint or joints.[6] The time spent living with chronic joint pain is described as an experience of pain: hiding pain and being hidden by pain, standing up to pain, and loss from pain.[7] Quality of life is negatively impacted through energy loss, sleep loss, and the need for recovery time, and can lead to depression and feelings of despair. Individuals may feel the need to hide the pain and withdraw from usual activities or contact with others in their lives.

Common coping strategies include the use of aphorisms, mind over matter, humour, adaptive living, and self-care. Patients also expressed experiences of loss in terms of work, finances, hobbies, sports, self-image, self-worth, and family roles. Service gaps were identified as lack of emotional supports, lack of physical supports, and lack of sustained access to professional support. The three components identified with successful management of OA were the availability of detailed knowledge and information, access to OA health professionals, and continued professional support along the journey of self-management.[8]

MANAGING OA

Like many other chronic diseases, the most effective strategies for OA self-management involve a multi-faceted approach adapted to the patient's specific needs and evolving as their needs evolve. This non-linear progression can be difficult to illustrate in a structured manner which can frustrate providers and patients alike.

Following diagnosis of OA, nearly 40% of Albertans will self-manage their disease (in partnership with their primary care team) for the rest of their lives.[13] The other 60% will spend, on average, 9 years self-managing their disease before receiving a specialist consultation.[13-15]

The AHS Bone and Joint Health Strategic Clinical Network (BJH SCN) has commissioned a Working Group and an expert Clinical Committee to develop a comprehensive provincial strategy for conservative OA management. Their initial mandate is to design system supports for the patients referred to a hip and knee surgeon that are designated as non-surgical. The more than 10,000 non-surgical patients represent about half of all hip and knee referrals in Alberta every year.

The Working Group has created an OA Conservative Management package that includes education classes, tools and structured support with a Navigator. This package is modelled after the Osteoarthritis Research Society International (OARSI) guidelines that promote education and training on self-management, followed closely by any type of exercise that is reasonable for the patient to undertake based on their symptoms and lifestyle (i.e. land based or water-based exercise). The OA Conservative Management package is being tested now in one of the Hip and Knee clinics of Alberta but has been designed to be easily transferrable to other care provider scenarios.

One of the challenges for patients navigating conservative treatment is that most of the treatment modalities fall outside of the publicly funded health system. Community educational programs, lifestyle coaching, exercise programs, physiotherapy, massage therapy, and dietary consultations are mostly privately funded. This results in inequity for patients unable or unwilling to fund these treatments out of pocket or who lack adequate private insurance coverage. This situation also leads patients who are financially able to entertain treatment options that are not based on scientific and medical evidence. Furthermore, this financial disincentive drives patients to consume (and often over-consume) publicly funded services instead of more appropriate alternatives for which they would have to pay out of pocket. Arguably, the result is over-utilization of diagnostic imaging, primary care, and prescription and over the counter analgesics.[16-22]

This gap in care may contribute to the perception that joint arthroplasty surgery is the "gold standard" service offering for patients suffering from OA. The lack of accessible public health services for the management of chronic OA between disease onset and end-stage signals to Albertans that surgical treatment is the only effective option to treat OA that is worthy of being publicly funded.

The divide between public and private care delivery in bone and joint health introduces a further complication by creating barriers to information on patient outcomes. Collaborating and sharing outcome information among for-profit providers could reveal trade secrets or jeopardize possible revenue opportunities, thereby increasing risk to the business and its profitability. Profit-seeking also introduces an unavoidable bias that contributes to the perception that some for-profit caregivers may prioritize revenue generation above patient-centred treatment recommendations.

This lack of reliable and unbiased data on the effectiveness and appropriateness of privately delivered services slows the progression of knowledge, creates uncertainty and distrust of the motives behind treatment recommendations, and prevents a full understanding on the cost-effectiveness of various treatment modalities. It may also slow the adoption of new treatment options in the public health system, by restricting the level of evidence available from private practice innovations.

The result is a complex navigation challenge where patients are forced to become subject matter experts in managing their disease. They are often faced with the difficult choice of paying out of pocket for privately-funded treatments of uncertain benefit, suffering with untreated joint pain until the disease progresses to end-stage, or aggressively pursuing scarce public services, with little guidance or information to assist in their decision-making.

The new OA Conservative Management package seeks to map out services that are available in a local region and to document associated wait times and costs, coupled with the support from a Navigator, an expert in these local options and in managing an OA flair will hopefully promote a change in culture with time. The Conservative Working Group and Clinical Committee will seek to build trusting relationships with these varied providers to expand delivery of the package and to secure data sharing agreements.

Most Albertans suffering from OA will self-manage their disease for the rest of their lives, adjusting their lifestyles as needed and using over-the-counter analgesics as their primary coping mechanisms. Of those that escalate to treatment by a clinician (physiotherapist, chiropractor, primary care physician, etc.), about 60% will eventually escalate to secondary treatment involving an orthopedic surgeon or rheumatologist consultation.[13] Of those seeking surgical care, only about half will proceed to surgery.

Of the entire population with OA, fewer than 15% will eventually proceed to arthroplasty surgery, and yet, at this time, many view that as the ultimate end-goal of their journey.[13]

ARTHROPLASTY: The surgical reconstruction or replacement of a joint.

From Greek *arthron* (joint) and *plastos* (molded, formed).

Table 1. A simplified approximation of the patient journey toward end-stage OA

New Onset OA (~1-2 yrs)	Prevalent (~5 yrs)	Primary Treatment (~4-5 yrs)	Secondary Treatment (~6 mo-2 yrs)	Tertiary Treatment (~1-2 yrs)
Symptom Onset and Diagnosis	Self-Management	Physiotherapy; Chiropractic Care; Massage Therapy; NSAIDs and injections; Primary Care; Lifestyle adjustment and/or exercise classes; Bracing/Aids	Specialist Care	Arthroplasty Surgery

Once a patient decides to pursue joint arthroplasty surgery, they begin a new journey that could last weeks, months, and sometimes years. The health system must coordinate all the resources necessary to deliver the care – the diagnostic tests, surgeon time, operating rooms, medical supplies and equipment, inpatient beds, hospital care teams, and rehabilitation resources, to name a few – which can take weeks or months. The standardized Alberta care pathway for elective arthroplasty requires that patients be ready, willing, and able to proceed with surgery and they must prepare themselves medically, socially, and functionally. For some, this will mean getting their health conditions under control (e.g. diabetes, hypertension, obesity). For others, it will require re-arranging their work, home, and family schedules to enable an extended recovery period (perhaps months in advance). While for others, it will involve improving their upper body strength conditioning and preparing their home to provide a safe recovery during their convalescence.

Finding the meeting point between the patients' readiness and the availability of system resources is partly responsible for the real and perceived delays in accessing surgery. Responsible stewardship of public health resources demands that there be a constant queue of ready, willing, and able patients to fill the available surgery capacity. This ensures an efficient and uninterrupted flow of patients through the system to maximize the natural bottlenecks (surgeon time, operating room time, bed capacity, etc.). However, when patients wait in this queue for extended periods, their medical tests will need to be repeated, their ability to maintain readiness and to keep their personal lives on hold will be limited, and their function will continue to decline.

Maintaining this balance between demand for service and the supply of scarce resources is a classical optimization problem: what is the ideal strategy for managing the surgical wait list that recognizes the needs of the patients, providers, and the health system to optimize various "outcomes?" To answer, one must first begin by quantifying the demand for arthroplasty.

Demand for Arthroplasty

FACTORS INFLUENCING DEMAND

The demand for arthroplasty is dependent on the prevalence of OA, even though only a small minority of OA sufferers will eventually proceed to arthroplasty surgery.[13] While arthritis can occur at any point in life, it more often occurs later in life. Nearly half of Canadians living with arthritis are over the age of 65 (**Figure 1**).[23] A 2009 Canadian census found that the average age of first OA diagnosis for any joint was 50.4 years, and between 47.6 and 53.4 years for joint pain.[1]

Obesity, a known risk factor for OA, is defined as "abnormal or excessive fat accumulation that may impair health." [24] BMI is a simple tool often utilized in the classification of obesity in adults, and the WHO classifies people with BMI ≥ 30 as obese, and BMI ≥ 25 as overweight.

Figure 1. Age of Canadians living with arthritis

Alberta's population is expected to grow by about 1.4% annually, reaching 6 million people by 2041, with the average age increasing from 37.9 (2017) to 41.6 (2041).[25] Simultaneously, BMI is continuing its generations-long upward trend, with 64% of Canadian adults over the age of 18 considered obese in 2017, up from only 49% in 1978.[25] Together, these two factors hint at strong upward growth in the future demand for arthroplasty.

Furthermore, not only is obesity a risk factor for the prevalence of OA, but evidence suggests that a BMI over 30 kg/m^2 increases the risk of surgical infections and complications, especially in knee replacement patients, although evidence does not support a BMI cut-off value for surgical candidacy.[25] Obesity is a complex chronic disease and not a singular health concern associated with bone and joint care. As obesity trends continue to rise in the population, an integration of several health management services is required to address implications of obesity on surgical demand for arthroplasty and the associated risk of surgical complications.

Other mechanisms for the development of OA also include trauma or repetitive stress injuries, such as from an accident, high impact level sport, or strenuous repetitive work activity. Following a joint injury, the impact on joint mechanics and/or deconditioning of the muscles leads to increased joint loads, contributing to the development of OA.[2; 3; 5] Even normal workloads following joint injuries can lead to the progression of OA. Pain and decreased physical activity also lead to weakening of muscles supporting the joints, in turn increasing the risk of falls and fractures.

In the absence of breakthroughs in the progress toward a cure for OA (which may not be a single disease), any long-term strategy designed to reduce the demand for arthroplasty must therefore follow a multi-pronged approach that focuses on:

1. Slowing the progression of OA through proven and effective conservative treatment modalities;
2. Improving the ability to self-manage OA and reduce dependency on opioids through better pain management, lifestyle modification, exercise, and coping strategies;
3. Reducing the incidence of obesity; and
4. Reducing the frequency of traumatic injury.
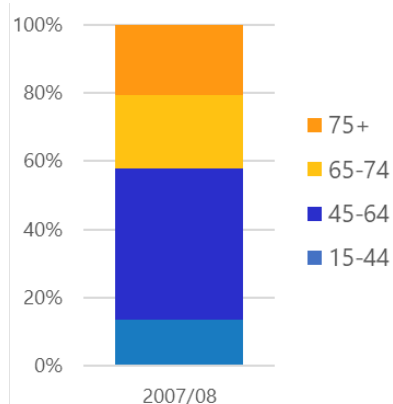
PROVINCIAL AND NATIONAL BENCHMARKS FOR ELECTIVE JOINT REPLACEMENT

In 2004, the First Ministers of Canada committed to creating evidence-based benchmarks for access to care across five priority areas: cancer, cardiac, diagnostic imaging, joint replacements, and sight restoration. In 2005, they endorsed the benchmark that 90% of all elective hip and knee arthroplasties should be performed within 26 weeks of consultation with the surgeon. This benchmark was based on clinical consensus and the rationale – which has been subsequently confirmed by research – that:

  a) Most OA-affected joints and the patients' HRQOL would be at high risk of significant deterioration after six months;[26-28]
  b) Evidence showing that the opposite joint could become damaged after six months due to gait irregularities, over-compensation for limitations of the affected joint, and loss of function;[26-29] and
  c) Patients' and providers' opinions that six months was the maximum acceptable time to wait for elective orthopedic procedures.[30-33]

In 2009, Alberta Health and Wellness established a Tier 1 Measure for elective hip and knee arthroplasty of 14 weeks, making it among the most progressive in Canada.[34] In support of the AHS *5-Year Health Action Plan*, the Bone and Joint Clinical Network (BJCN) requested modelling to support a plan to reduce the wait times for elective hip and knee arthroplasty in Alberta to under 14 weeks at the 90th percentile. The BJCN included the plan entitled *Meeting Alberta's Wait Times Target for Hip and Knee Replacements* in a briefing note to AHS Executive which called for:

  a) Significant zone-specific surgical volume increases in the first two years that would harmonize waits across the province (**Figure 2**);
  b) Re-investment of efficiencies into hip and knee arthroplasty to partially offset the incremental costs associated with the volume increases;
  c) Volume increases in years 3-5 of approximately 1% above annual demand (**Figure 3**); and
  d) Annual recalculation of demand projections to incorporate new data and outcomes.

This plan was accepted by the AHS Clinical Operations Executive Council and the first year of surgical volume increases began in fiscal year 2011/12.

Figure 2. Number of hip and knee replacements needed to achieve target (14 weeks) by 2015/16.
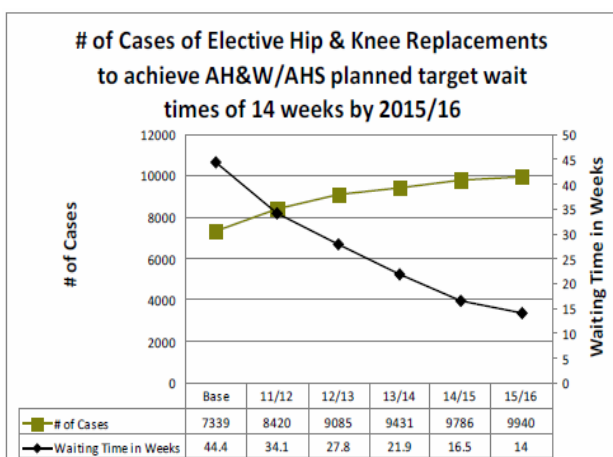
Figure 3. Projected 90th percentile waiting times under various volume scenarios.

	Base	11/12	12/13	13/14	14/15	15/16
# of Cases	7339	8420	9085	9431	9786	9940
Waiting Time in Weeks	44.4	34.1	27.8	21.9	16.5	14
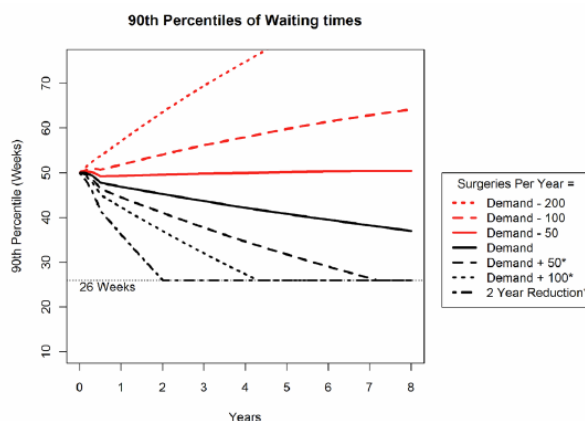
*In these scenarios, surgical rate equals demand after target of 90th percentile for waiting times is achieved.

As the surgical volume increase proceeded, wait times initially climbed as long-waiting patients were cleared from the backlog, peaking near 47 weeks at the 90th percentile, before descending gradually throughout fiscal 2012/13. The 90th percentile wait times bottomed out at 40 weeks (13% overall reduction from peak) at the end of 2012/13 (**Figure 4**).

Despite the significant volume increases over the first two years of the plan, efficiencies in acute length of stay and subacute utilization resulted in only minor increases in hospital bed use. This trend started with the launch of the integrated care pathway in 2004/05 and continues to present day. From the launch of the pathway in April 2004 to the end of the planned volume increases in March 2013, annual surgical volume had grown by 73%, whereas acute care bed use had climbed by only 5% (**Figure 5**). It is estimated that $34.9 million of cumulative inpatient and subacute capacity was released over the first two years of the plan to partially offset the incremental costs of the volume growth.

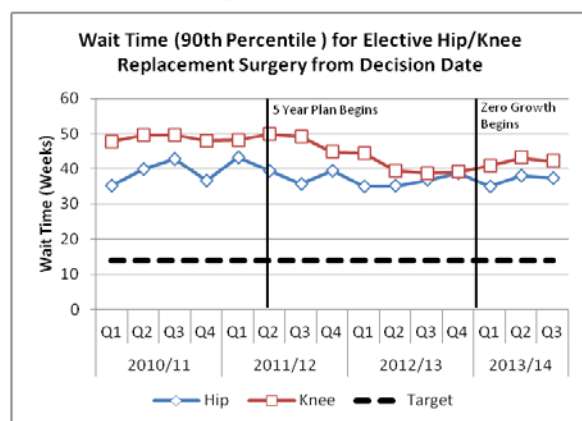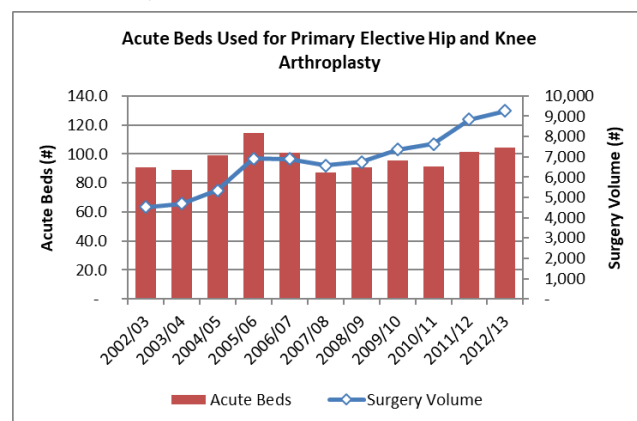**Figure 4. Wait time (90th percentile) from decision to surgery date.**

Figure 5. Reinvesting length of stay efficiencies into arthroplasty and other services.

In 2012/13, financial pressure from reduced government revenues forced Alberta Health Services to retreat from the 5-year plan and to adopt a zero-volume growth policy. Since then, wait lists have grown considerably and wait times have correspondingly increased.

Key observations from the first two years of surgical volume increases:

- **Retrospective measurement of wait times at the 90th percentile change (very) slowly.**
  As the backlog of patients are cleared through targeted volume increases, retrospective measures that look at past performance, such as the 90th percentile wait times, will initially worsen as the longest waiting patients receive surgery. Furthermore, the measures only showed improvement after a period of 1 to 1.5 years following the volume growth.
- **Prospective measurement of wait times tell a different story than retrospective measures.**
  Prospective modeling of wait times predict the wait experience for newly arriving patients and more accurately reflect the current reality than retrospective measures. These forward-looking projections estimate the wait time for the next patient in the queue, and are influenced by the current size of the wait list and surgery volume being performed. They are not influenced by past performance or how long previous patients have waited. These are important tools for communicating with patients and setting realistic expectations.

- **Access to care is a complex system with multiple bottlenecks, and optimizing one part in isolation does not improve the overall patient experience.**
  The patient care experience involves several stages with many transitions that are currently unmonitored: from self-management to primary care, from primary care to specialty care, from specialist consultation to surgical intervention and finally to post-surgery recovery. Focusing on the transition from specialist consultation to surgery alone often results in sub-optimization, for example where patients have relatively rapid access to surgery, but only after waiting years for their surgeon consultation.
- **Wait time for consultation is highly sensitive to changes in surgery volume.**
  Clinic consultation activity is strongly related to surgery volume allocations. About half of the patients referred for hip and knee arthroplasty proceed to surgery, so patient consultation volume increases and decreases twofold with changes in surgery volume allocations to maintain the balance between an uninterrupted queue of surgical patients and minimizing the duplication of medical tests and physical assessments (most lab tests and diagnostic imaging needs to be repeated after 3-6 months).
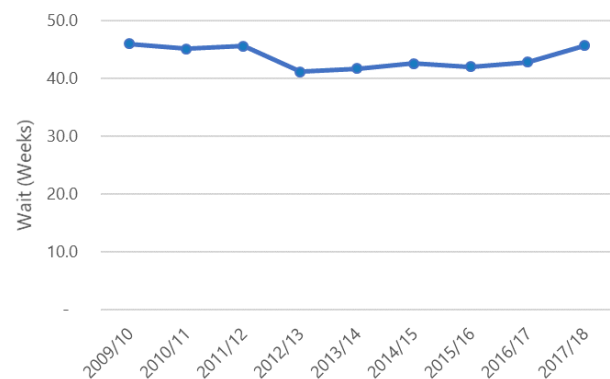
CURRENT AND FUTURE PERFORMANCE

An examination of 90th percentile wait times would suggest that the current system performance has remained relatively stable since the end of 2012/13 with only minor deterioration in performance in recent years (**Figure 6**). However, one must look beyond the 90th percentile to appreciate the impact of the past several years of zero volume growth.

Examining the change in the distribution of waiting times demonstrates how much the wait experience has deteriorated for most patients. In 2009/10, as the 90th percentile was approaching one year, the waiting times were often described as being in "crisis."[35; 36] The median wait at the time was 15.6 weeks, and 27.1% of patients had wait times that exceeded the 26 week national benchmark.

Figure 6. Wait times (90th percentile) from decision date to surgery date for primary elective hip and knee arthroplasty.

The distribution of wait times had a strong skew to the right – the product of a small proportion of patients (relatively speaking) that had prolonged waits for surgery (**Figure 7A**). Following two years of surgery volume increase, there was measurable progress with a much smaller proportion of patients waiting more than 52 weeks and moderate shift to the left in the middle of the distribution (20 to 44 weeks) (**Figure 7B**).

As of 2017/18, the 90th percentile has returned to 45.7 weeks, but the median wait has now climbed to 24.0 weeks, a 54% increase in wait time for the "typical" patient (**Figure 7C**). More alarmingly, 43.5% of patients now exceed the 26-week benchmark. Any intervention to reduce the 90th percentile to under 26 weeks must now reduce the waiting time for thousands more Albertans to shift the overall wait to within acceptable parameters.

Fiscal Year 2009/10 (a)	Figure 7. Distribution of wait times for surgery over multiple fiscal years
• Significant skew to the right of the distribution • 90th percentile wait 46 weeks • Median wait 15.6 weeks • Waiting times described as a "crisis"	**Distribution of Wait Times for Primary Elective TJA (FY2009/10)** 90th Percentile Wait from Decision to Surgery (Weeks)
Fiscal 2012/13 (b) • End of two years of volume uplift • Measurable reduction in rightmost skew of tail • Moderate shift to the left in the middle of the distribution • 90th percentile 40 weeks • Median wait 15.7 weeks	**Distribution of Wait Times for Primary Elective TJA (FY2012/13)** 90th Percentile Wait from Decision to Surgery (Weeks)
Fiscal 2017/18 (c) • Considerable migration to the right in the middle of the distribution • 90th percentile 46 weeks • Median wait 26.9 weeks	**Distribution of Wait Times for Primary Elective TJA (FY2017/18)** 90th Percentile Wait from Decision to Surgery (Weeks)

The wait for surgery data presented above, however, does not capture the "hidden demand" that has amassed within the surgeon offices. As witnessed during the surgery volume uplift, clinic capacity to assess and prepare patients for surgery responds two-fold to changes in the allotment of surgery volume. Following the adoption of a zero-growth strategy in surgery volume, wait times for surgeon consult have increased above pre-uplift levels (**Figure 8**).

Figure 8. Wait times for new surgeon consult for primary elective joint arthroplasty.
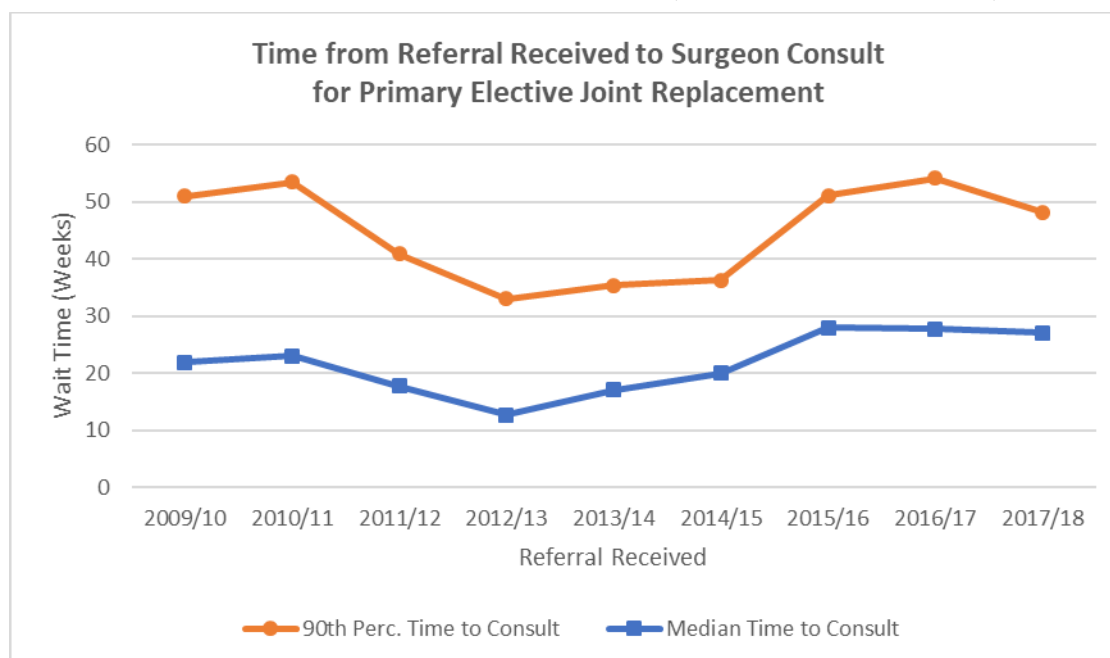
Additionally, the distribution of wait times for surgeon consult are much more heavily skewed to the right than they were previously (**Figure 9A through C).** Based on the experience of the pr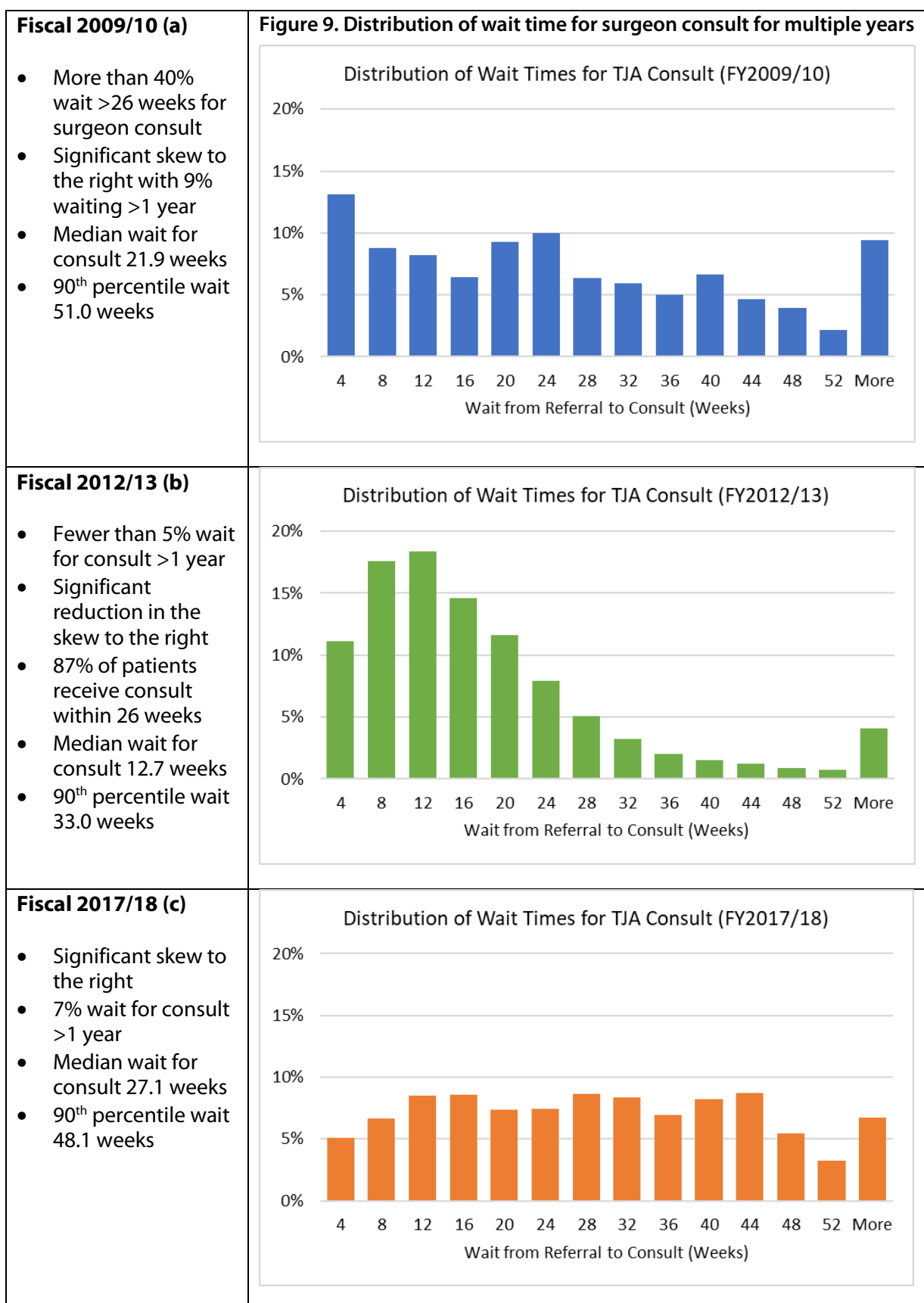evious surgical uplift, the province can anticipate a significant backlog of surgery demand to hit the queue for surgery filled with patients having already waited more than six months for consultation. Indeed, more than half of patients referred for surgeon consult in 2017/18 waited more than 26 weeks for consult (**Table 2**).

Table 2. Wait times for surgeon consultation

Referral Fiscal Yr	New Referrals (#)	Surgeon Consults (#)	Wait > 26 Weeks (%)	Median Wait for Consult (Weeks)	90th Perc. Wait for Consult (Weeks)
2009/10	3,935	3,070	40.9	21.9	51.0
2010/11	4,853	4,123	46.5	23.0	53.4
2011/12	7,102	6,146	29.4	17.7	40.9
2012/13	8,365	7,032	16.1	12.7	33.0
2013/14	10,839	9,235	21.9	17.1	35.4
2014/15	13,265	11,036	32.6	20.0	36.3
2015/16	13,947	11,486	53.4	27.9	51.1
2016/17	13,297	10,582	52.0	27.7	54.1
2017/18	12,322	8,414	52.3	27.1	48.1

Fiscal 2009/10 (a)	Figure 9. Distribution of wait time for surgeon consult for multiple years
• More than 40% wait >26 weeks for surgeon consult • Significant skew to the right with 9% waiting >1 year • Median wait for consult 21.9 weeks • 90th percentile wait 51.0 weeks	**Distribution of Wait Times for TJA Consult (FY2009/10)** Wait from Referral to Consult (Weeks)
Fiscal 2012/13 (b) • Fewer than 5% wait for consult >1 year • Significant reduction in the skew to the right • 87% of patients receive consult within 26 weeks • Median wait for consult 12.7 weeks • 90th percentile wait 33.0 weeks	**Distribution of Wait Times for TJA Consult (FY2012/13)** Wait from Referral to Consult (Weeks)
Fiscal 2017/18 (c) • Significant skew to the right • 7% wait for consult >1 year • Median wait for consult 27.1 weeks • 90th percentile wait 48.1 weeks	**Distribution of Wait Times for TJA Consult (FY2017/18)** Wait from Referral to Consult (Weeks)

ARTHROPLASTY DEMAND FORECASTS

Short-term changes in demand for arthroplasty are driven mostly by changes in population and the distribution of age and sex. Medium- and long-term changes in the rate of demand for arthroplasty may also be influenced by:[4; 5; 37]

- Longer life expectancy;
- Prevalence of obesity;
- Traumatic injury; and
- Consumerism resulting from positive word-of-mouth, elevated media attention, and growing social acceptance of elective surgery.

The methods used to forecast arthroplasty demand are detailed in Appendix A: Methods. It is assumed that the per-capita rate of demand will remain relatively unchanged over the life of the model, and that any impact from initiatives to reduce the rate of demand for arthroplasty will fall outside the time window of this model.

Table 3. Projected demand for primary, elective arthroplasty by health zone

Zone	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28
South	1,259	1,287	1,316	1,344	1,373	1,401	1,427	1,453	1,476	1,497
Calgary	4,652	4,828	5,011	5,199	5,384	5,572	5,761	5,947	6,125	6,287
Central	1,094	1,121	1,150	1,180	1,209	1,237	1,266	1,292	1,316	1,338
Edmonton	4,006	4,130	4,255	4,385	4,511	4,642	4,773	4,900	5,021	5,135
North	891	914	939	963	989	1,015	1,040	1,065	1,089	1,109
ALBERTA	11,902	12,281	12,671	13,071	13,466	13,867	14,267	14,657	15,028	15,366
Yearly Growth		3.2%	3.2%	3.2%	3.0%	3.0%	2.9%	2.7%	2.5%	2.2%

Table 4. Crude rate of arthroplasty per 100,000 residents

Zone	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28
South	543.0	551.1	558.8	566.6	573.6	580.7	586.6	591.3	595.5	598.5
Calgary	356.7	364.4	371.8	379.1	386.4	392.9	398.9	404.5	409.7	413.9
Central	295.8	301.4	306.4	311.8	317.1	321.6	325.8	329.9	333.2	335.6
Edmonton	366.6	372.7	378.8	384.8	390.9	396.2	401.4	406.3	410.6	414.1
North	246.5	251.7	256.3	260.9	265.3	269.7	273.7	277.5	281.0	283.9

Table 5. Age-sex standardized rate of arthroplasty per 100,000 residents

Zone	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28
South	475.8	484.4	492.6	500.8	508.9	516.1	522.7	528.8	534.2	538.3
Calgary	369.3	376.3	383.1	389.8	396.4	402.4	408.0	413.2	417.8	421.5
Central	256.4	261.5	266.5	271.4	276.2	280.5	284.5	288.2	291.6	294.2
Edmonton	371.1	377.9	384.4	390.9	397.3	403.1	408.6	413.6	418.1	421.8
North	271.7	277.1	282.2	287.3	292.4	297.0	301.5	305.7	309.5	312.7
ALBERTA	354.2	361.0	367.5	374.0	380.3	386.1	391.4	396.4	400.9	404.5

"Taming of the Queue"

There are three components required to successfully resolve the access gap in OA care and eliminate the surgery waiting times crisis:

1. Address the current backlog of demand for arthroplasty thereby reducing wait times to an acceptable level;
2. Maintain sufficient surgical capacity to address future demand for arthroplasty; and
3. Reduce the rate of future demand for surgery by introducing effective and accessible prevention and conservative self-management programs.

ADDRESSING THE CURRENT BACKLOG

It is estimated that demand for arthroplasty is 11,902 Albertans (FY2018/19), which is 9.8% above the funded arthroplasty surgery volume. Without a significant increase in the level of funded surgery, about 1,066 new Albertans will be added to the wait list every year. This demand will be shared unequally between the wait list for surgery and the wait list for consultation, with more than half of the unmet demand going unmeasured by the current Alberta Health and AHS performance measures.

The impact on wait times under five different scenarios that each consider a different approach to managing the current demand for arthroplasty has been projected below. The scenarios forecast the surgery volume increases required to provide surgery within 26 weeks to 90% of patients.

For every model except zero growth, volume increases are set to exactly match the demand for surgery once the 26-week target has been met. Under zero growth, the volume remains unchanged throughout the entire forecast period.

1. **Zero Growth**
   The impact on wait times if the policy of zero growth in volumes continues indefinitely.
2. **Five-Year Reduction to 26 Weeks**
   The year-over-year volume increases needed such that 90% of patients who are ready-to-treat (i.e. no patient-related reasons for delay) would receive surgery within 26 weeks at the end of five years, using equal annual percentage increases.
3. **Seven-Year Reduction to 26 Weeks**
   The same as model 2 with the timeframe extended to seven years.
4. **Demand Only**
   The impact on wait times if surgery volume exactly matched the projected demand, essentially freezing wait lists at their current sizes.
5. **Front-Loaded Five-Year Reduction to 26 Weeks**
   Like model 2, but with larger increases in the first 2 years and diminishing increases thereafter.
6. **Four-Year Reduction to 16 Weeks**
   The year-over-year volume increases needed such that 99% of patients who are ready-to-treat would receive surgery within 16 weeks at the end of four years, using equal annual percentage increases.

Table 6. Forecasted surgery volumes and 90th percentile wait times under multiple scenarios

	Scenario	YEAR 1 2019/20	YEAR 2 2020/21	YEAR 3 2021/22	YEAR 4 2022/23	YEAR 5 2023/24	YEAR 6 2024/25	YEAR 7 2025/26	YEAR 8 2026/27	YEAR 9 2027/28
Surgery Volume	Zero Growth	10,836	10,836	10,836	10,836	10,836	10,836	10,836	10,836	10,836
	5 yrs; 26 wks	11,653	12,542	13,510	14,562	15,213	14,267	14,657	15,028	15,366
	7 yrs; 26 wks	11,485	12,177	12,918	13,711	14,559	15,466	16,436	15,028	15,366
	Demand Only	12,281	12,671	13,071	13,466	13,867	14,267	14,657	15,028	15,366
	Front-Loaded	12,430	13,410	13,825	14,215	14,114	14,267	14,657	15,028	15,366
	4 yrs, 16 wks	12,110	13,549	15,176	17,016	13,867	14,267	14,657	15,028	15,366
Wait Times	Zero Growth	61.6	73.6	88.2	105.4	125.2	147.6	172.5	199.9	229.5
	5 yrs; 26 wks	48.6	45.8	40.4	33.6	29.1	26.1	25.5	24.9	24.4
	7 yrs; 26 wks	51.1	50.8	48.7	44.7	38.9	31.4	26.0	25.4	24.9
	Demand Only	44.6	43.3	42.0	40.8	39.6	38.6	37.6	36.8	36.0
	Front-Loaded	41.4	36.4	31.6	28.1	26.6	25.4	24.8	24.2	23.7
	4 yrs; 16 wks*	79.4	63.3	40.1	15.5	15.1	14.7	14.3	14.0	14.0

NOTE: All wait time forecasts are at the 90th percentile (except * which is 99th percentile) for patients that are ready-to-treat (i.e. no patient-related delays) and apply from the end of the reported period (i.e. for newly arriving patients).

The projected wait times under the listed scenarios are displayed graphically in **Figure 10**.

Figure 10. Forecasted wait times under multiple scenarios
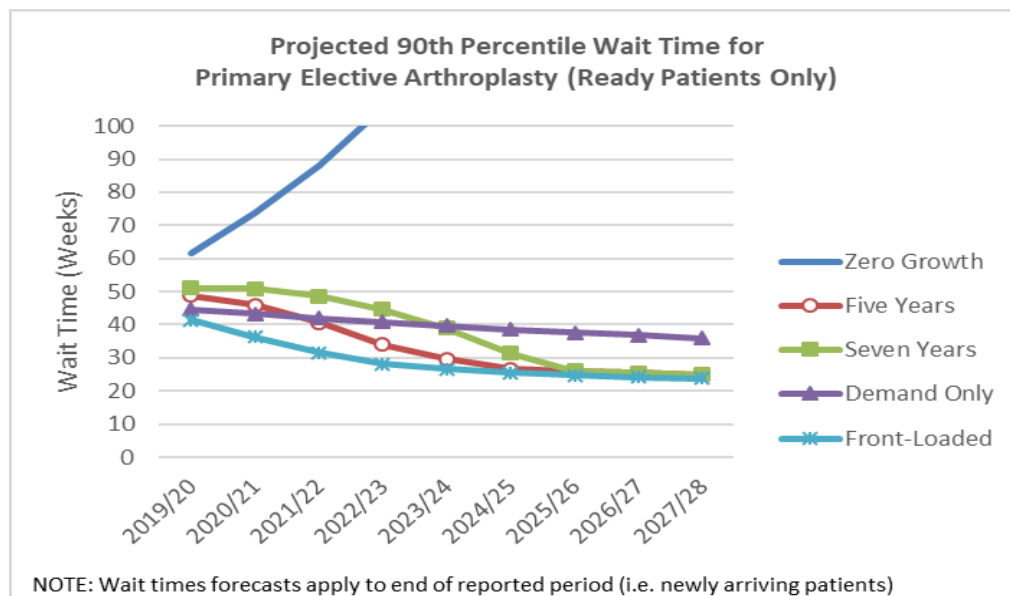
Once the wait times have reached 26 weeks at the 90th percentile, the year-over-year annual increase required to meet future demand is estimated between 2.5 and 3.0%. This anticipated growth in arthroplasty demand is driven entirely by population growth and changing demographics (shifts in the distribution of age and the male/female balance) over time.

Assumptions

The following assumptions were included in these forecasts; any adjustments to these assumptions would alter the model's results and require recalculation:

- Surgery volume uplift will begin in 2019/20 (YEAR 1);
- Surgery volume for 2018/19 (YEAR 0) will be unchanged from 2017/18;
- The proportion of patient-driven delays will not change over the forecasted timespan;
- The general shape of the distribution of wait times will remain about the same throughout the forecasted timespan[*];
- The rate of demand for arthroplasty will remain unchanged over the forecasted timespan; and
- There are no operational or resource limitations (e.g. operating room time, inpatient bed capacity, surgeon capacity) restricting the ability to increase volume to the required levels.

REDUCING DEMAND

The only way to successfully change demand for arthroplasty over the long-term is to:

1) change the modifiable risk factors that contribute to the prevalence of OA, and

2) develop effective strategies for slowing the disease process.

The BJH SCN is pursuing a multi-pronged strategy to progress in this area (**Figure 11**):

- Support the introduction of neuromuscular training to reduce sports-related lower limb injuries;
- Engage with researchers, clinicians, and patients to better understand the unique intersection and interplay between obesity and OA;
- Develop risk-management strategies to better identify and manage obesity-related risk in the surgical population; and
- Test multiple conservative management strategies to empower and support patient self-management.

There is currently weak evidence for the effectiveness and appropriateness of OA conservative treatments and therapies, leaving many patients unsure of how to proceed in preventative care and management of the disease.[12; 16; 38-40] Many of the programs and therapies appropriate for supporting OA management are under-utilized as patients often seek out publicly funded services to avoid out-of-pocket patient expenses.[41] The lack of evidence-base tied with the cost disincentive for seeking privately funded programs and supports is a gap in care which the BJH SCN is working to strategically address.

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[*] This assumption will almost certainly not hold true. The selection and prioritization of patients to fill available operating room slots is highly unpredictable and is influenced by the complex interaction of clinical triage, human psychology, and resource allocation. Previous attempts to predict how the shape of the distribution will change over time using simulation modeling has performed poorly, so we elect to keep the shape of the distribution static throughout the forecasting timespan.

Due to the chronic and progressive nature of OA, optimal treatments rarely remain static. For this reason, a combined approach of OA self-management and education and availability of health system supports will reduce the confusing and complex navigation that OA patients face in Alberta, while simultaneously reducing inappropriate service use. With no "cure" or singular treatment for OA, the intent is to support Albertans on slowing or halting the progression of OA. Ultimately, prevention strategies are also needed to impact the prevalence of the disease.

The BJH SCN has been piloting a conservative management exercise-based program - GLA:D® Canada - aimed at people who have osteoarthritis in the knees and hips. Based on research from GLA:D® in Denmark, the evidence-based 8-week program includes education sessions (introduction to OA, current available treatments, symptom self-management, exercise benefits and coping strategies) and exercise

Figure 11. Long-term SCN strategy to reduce demand for arthroplasty

sessions led by GLA:D-certified therapists.[42] Uptake of the program across Alberta has been patient-driven, as patients continue to show interest in the program, and an evaluation of its effectiveness and long-term sustainability is under way.

The BJH SCN has established groups of multi-disciplinary stakeholders whose mandate is the development of a system-supported care and service delivery model for 10,000+ patients referred annually to orthopedic surgeons for joint replacement who are not appropriate surgical candidates or who decide not to proceed to surgery. With the knowledge that OA is a chronic disease, emphasis is placed on self-management of OA symptoms. Patients will be educated on how best to manage their symptoms and health and on availability of system supports, both aligned with their personal goals and life circumstances.

UNDERSTANDING THE PATIENT JOURNEY

The OA patient journey is a complex path that requires understanding of the many treatments, coping strategies, and outcomes that patients experience. Dr. Deborah Marshall at the University of Calgary has built a sophisticated Systems Dynamics (SD) mathematical model that plots public health system interactions of Albertans living with OA from the initial diagnosis to end-of-life.[13-15; 43-45]

The SD model, created as part of a CIHR operating grant, provides the best picture available into the OA patient journey that is informed by real-world data from the Alberta public health system and the Alberta Bone and Joint Health Institute's data repository. It includes patient interactions with physicians and other care providers, the associated public-health care costs, and describes the various care transactions that occur throughout the patients' lifetime journey.

The CIHR operating grant supported the creation of the SD-OA model and provided the initial dataset on which it was built. Like most research funding, the project's conclusion has brought development on the model to an end and cannot sustain or support the refresh of the model's data.

The SD-OA model is a valuable planning tool that could enable health system planners to ask crucial "what-if" questions and predict the likely impacts of changes to the system. In this way, one could manipulate the flow of patients through the system, change the availability or effectiveness of treatments, or re-sequence health system interactions on paper and monitor the results, without the need for expensive or risky system redesign initiatives. It could also help identify unanticipated side-effects to changes being considered so that they could be mitigated or avoided altogether.

This model is ideally suited to predict the future impacts of long-term interventions that alter the demand for arthroplasty or the progression of OA.

HEALTHY LIVING

It is clear from the recent history of the Hip and Knee OA Project that the queue for arthroplasty can be impacted by increasing the number of operations performed, with a corresponding shortening of wait times for surgery. However, unless one addresses the upstream input into the queue, the bottleneck of wait times to see a surgeon and to have a joint replacement will continue to again increase. Therefore, one must address the upstream need or there will be constant cycles of the bottleneck that will need to be addressed. The longer life expectancy of Albertans and increased rate of obesity are two factors accentuating the need for a focus on lifestyles that promote health, including good bone health to offset the increasing demand for surgery.

To address the upstream aspects of the queue likely one needs to implement two initiatives. The first is to develop conservative management strategies for those with a diagnosis of early OA which will inhibit/delay or prevent the progression of disease to the point of arthroplasty. Currently, the BJH SCN is moving into the realm of conservative management with the implementation of the GLA:D® exercise program and others.

The second initiative relates to development of prevention strategies via Healthy Living with exercise, good nutrition, control of weight, and conservative interventions to minimize risk for joint injury. Effective Injury prevention programs will reduce the percentage of individuals who progress to more severe OA and in some cases, delay the onset of OA. When combined with trusted, well researched programs that support patient self-management of OA, these early intervention type initiatives support patients in their lifelong OA journey. While the impact of prevention initiatives has a long timeframe and is challenging to quantify, these strategies will lead to a healthier population of Albertans with positive repercussions felt beyond OA and MSK conditions; healthy living will positively impact cardiovascular, brain, respiratory, and general health – areas having an increasing burden on the strained public health system. It will require a shift to an "across the lifespan" approach to develop a culture of healthy living in childhood all the way to aging and the elderly. This approach aligns with patients expressed desire for reliable sources of information on how to prevent or delay OA from occurring and to equip individuals with exercises, programs and easy access to assessment, consultation and system wayfinding when their condition requires health profession intervention.

To implement the first initiative, one must shift from the current "sick care" system that responds to disease and injury, to a "health care" system that promotes health and healthy living. Such a system will require the support from a different mix of health professionals than is generally funded under the *Alberta Health Care Insurance Plan*, including physiotherapists, occupational therapists, kinesiologists, and nutritionists, in addition to the existing family physicians and primary care networks.

The second initiative will require a further shift away from the acute care sector into the community, including engaging the education system and the general population. This will also require a shift to a "shared responsibility" for health between the individual and the health care system. However, the approach aligns with other Alberta initiatives related to Action Schools, Sport Alberta, and others, so

the infrastructure to make an impact is partially in place, but perhaps needs improved integration to enhance its impact. This will build on the current SCN-supported initiatives underway to minimize risk for sport-related MSK injuries in adolescent populations. There is great opportunity to partner with multiple SCNs and stakeholders representing a broad spectrum of health conditions to maximize the impact of healthy living initiatives.

LONG TERM SURVEILLANCE

A single health record for all health, and certainly for bone and joint health related conditions, will contribute to better prediction of individual and provincial level health care needs, as well to plan for, coordinate and evaluate care. Further, establishing linkage between injuries and conditions that Albertans experience in a longitudinal health record will inform prevalence and incident rates of OA and other MSK related conditions and disorders, which in turn will be instrumental in evaluating long term health promotion impacts. Data collection from all providers in the public and private system involved in addressing musculoskeletal concerns of Albertans will inform the effectiveness of all parts of the continuum and contribute to greater collaboration and more seamless transitions among providers.

CONCLUSION

For over a decade, a province wide collaborative multidisciplinary team has developed, implemented, evaluated and refined a care pathway for hip and knee arthroplasty. Sites are now working to sustain the hip and knee surgical pathway locally, while still connecting with peers to share lessons learned and address new challenges. The central intake clinics for hip and knee arthroplasty continue to evolve in response to patient need. Attention is being focused on addressing the specific needs of the 10,000 plus referrals deemed "non-surgical" that attend these clinics annually. The piloting of interventions for this group will result in ongoing revisions and implementation to relevant clinics across the province. Addressing comorbid obesity will be one area of focus and opportunity for collaboration with clinical and academic partners. Advances will continue to be made in principles and approaches such as shared decision making, ensuring the patient perspective, preference and commitments are incorporated into care plans. It is critical the Alberta bone and joint community continues to take an integrated approach to plan, implement, study and scale evidence-based interventions across the OA patient journey to prevent OA disease and its progression, and to ultimately bend the cost curve and the impact this chronic disease has on Albertans and our health system.

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Appendix A: Methods

DEMAND MODELING

Population and demographic distribution by Health Zone were obtained from the Alberta Government Interactive Health Data Application (IHDA) (http://www.ahw.gov.ab.ca/IHDA_Retrieval/ihdaData.do) using the "Demographics, Population Projections by Zone – 2018 to 2047" data set. Age and sex distributions by Health Zone for 2011 to 2017 (actual) and 2018 to 2028 (projected) were extracted from IHDA. Age groups were combined to form 10-year categories with all ages 90 and above aggregated into a single category (i.e. 0-9, 10-19, 20-29, 30-39, 40-49, 50-59, 60-69, 70-79, 80-89, 90+). The first two categories (0-9 and 10-19) were discarded, resulting in population distributions and projections for Albertans over 20 years of age, stratified by sex and eight (8) age groups.

Surgery volumes from the Discharge Abstract Database (DAD) and operating room information systems was used to measure the number of primary elective arthroplasty procedures. Surgeries were linked to clinic EMR data where available to identify the date of referral to orthopedic specialist. In instances where referral data was missing, the average time from referral to consult and consult to surgery for that zone in that year was substituted to estimate the timing of referral.

The annual volume of surgical referrals by date of referral was used as the best estimate of demand for arthroplasty by fiscal year, stratified by joint, sex, and 10-year age group. Complete data was available across the province for fiscal years 2014/15 through 2016/17. Annual demand was converted to a rate per capita for each of the sex and age group strata and a 3-year average rate per capita was calculated. The cumulative zone rates were then converted to age-sex standardized rates per 100,000 residents.

Annual projections for arthroplasty demand for each health zone were calculated from 2018 through 2028 using the Alberta government demographic projections and the calculated zone-specific three-year average rate per capita.

Clinic EMR data from Calgary, Edmonton, Red Deer, and Lethbridge were used to calculate the size of the surgical wait list at the beginning of 2017/18. Surgery volumes for 2018/19 was estimated based on the assumption that the volume would remain unchanged from 2017/18. Estimates of the size of the wait list from the other clinics (Medicine Hat, Camrose, Grande Prairie, Westlock, and Bonnyville) were obtained from clinic staff.

Assumptions:

- Funded surgery volume for 2018/19 remains unchanged from the volume in 2017/18
- All patients that decide to have surgery, eventually receive surgery and nobody balks or withdraws consent
- The average rate of arthroplasty demand for 2014-2017 approximates the current demand for arthroplasty
- No major change in the rate of demand for arthroplasty is expected over the next five years

WAITING TIME PROJECTIONS

There is no mathematically proven method to predict 90th percentile waiting times for a queue in which service is allocated unpredictably, such as when patient triage is used. Simulation modeling can be used to estimate the future distribution of queues using statistical predictions.

In 2009, the Alberta Bone and Joint Health Institute employed Monte Carlo simulation using 10,000 iterations to attempt to predict the change in the distribution of a fictional wait queue with similar properties to the actual surgical wait list. Patients in the queue were selected to receive surgery stochastically, with preference given to longer-waiting patients. The average from the 10,000 simulations was used to predict the likely 90th percentile under multiple scenarios.

Unfortunately, the simulation performed no better than simple arithmetic conversions of the projected mean to an estimated 90th percentile using a slowly declining 90th-mean ratio. Furthermore, the simulation model required substantial recalibration as new data became available, and it required several weeks of effort to update the projections every time new assumptions were introduced, or goals were changed.

Ultimately, the Alberta Bone and Joint Health Institute adopted a more simplistic and utilitarian approach, where estimated mean waiting times are converted to 90th percentiles using a slowly declining 90th-mean ratio. This approach had the benefit of being simple enough to embed into a spreadsheet, while adequately emulating real-world outcomes.

Alberta's historical wait times distribution are heavily right-skewed, with a 90th-mean ratio that hovered between 1.8 and 2.1. The current distribution of wait times more closely resembles a normal distribution, with a 90th-mean ratio ranging between 1.5 and 1.8.

Future mean waiting times are estimated using the formula:

$$\frac{Wait\ List\ Size_{End\ of\ Current\ Period}}{Projected\ Surgical\ Volume_{Next\ Period}} \times 52\ weeks = Avg\ Wait\ (in\ weeks)_{Next\ Period}$$