Digital musculoskeletal impact on medical claims: 136 employer study

The largest-ever medical claims analysis of a digital MSK solution demonstrated that Hinge Health reduces medical claims by $2,387 per participant compared to a control group, delivering a 2.4x ROI. This cost study's methodology, assumptions, savings feasibility, and credibility were independently reviewed by a global leader in actuarial science.

Executive Summary

Hinge Health's chronic pain program is a digital care program designed by physical therapists and physicians that helps members manage chronic musculoskeletal (MSK) pain. To demonstrate value to current and future clients, Hinge Health conducted a cost study about the impact of the Hinge Health chronic pain program on medical care costs and utilization. The study leveraged a well-curated claims database that represented more than 100 million commercially insured members from January 1, 2016, to September 30, 2021. This cost study's methodology, assumptions, savings feasibility, and credibility were independently reviewed by a global leader in actuarial science.

To estimate savings, the study compared Hinge Health members' 12-month pre-to-post changes in medical care costs and utilization to those of a control group. Hinge Health members with nonsurgical MSK claims at baseline started the Hinge Health chronic pain program for back, hip, knee, neck, or shoulder pain in 2020. The control group comprised nonparticipants with nonsurgical MSK claims at baseline who received conservative care for back, hip, knee, neck, or shoulder pain in 2020. This study applied a propensity score matching method to identify a control group that was similar to Hinge Health members on these baseline characteristics: age, gender, geographic region, comorbidities, MSK services utilization, MSK cost, and overall medical care cost.

The study of 8,414 participants (4,207 Hinge Health members from 136 employers and 4,207 control group members) demonstrated a per-member-per-year (PMPY) medical claims reduction of $2,387 with respect to overall chronic MSK cost, or a 2.4x return on investment ($2,387 annual savings divided by a $995 Hinge Health program fee). The majority of savings came from lower surgery costs (39%). The largest reductions in service utilization between the two groups were in imaging, injections, durable medical equipment, and surgery.

In conclusion, the Hinge Health chronic pain program produced statistically significant savings and a 2.4x ROI among those who recently received in-person, nonsurgical care for their MSK conditions. The Hinge Health program helps employers and payers avoid costs from MSK medical claims, especially from elective surgeries. The study results can help guide employers and payers making decisions about benefits offerings that most effectively manage rising MSK costs.

Study summary

(*n* = 8,414 participants)

2-year study

136 employers

46 industries

$2,387

medical claims reduction per member per year

2.4x

ROI

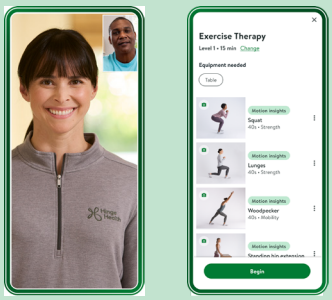
Conclusion

Hinge Health's chronic pain program produced statistically significant savings and a 2.4x ROI among those who recently received in-person, nonsurgical care for their MSK conditions.

Background

Exercise and education are best practices for helping people manage MSK pain and associated comorbidities (1–8). Digital health approaches are among the newest methods for delivering these conservative therapies and can significantly reduce MSK pain and disability (9–11).

Hinge Health is a digital program with the goal of helping members manage MSK pain. Designed by physical therapists, the program includes three key components:



Exercise therapy with TrueMotion computer vision technology

Animations and videos, shown in an app on the member's own device or a complimentary tablet, demonstrates how to perform exercises (e.g., position, repetitions, duration). Computer vision provides guidance to members on correct exercise form.

Educational resources

The program app provides educational resources about

- Pain neuroscience
- Movement
- Treatment options
- Coping
- Lifestyle changes
- Relaxation
- Social support
- Habit creation

Support from a comprehensive clinical care team

The care team includes a doctor of physical therapy and a health coach. The care team develops individualized care plans and encourages members to complete at least three playlists per week and to adhere to the program. Physical therapists focus on members' physical recovery and are responsible for customizing and adjusting members' care plans. Health coaches work with members to set goals, identify challenges in performing exercises, and implement strategies to overcome challenges.

136 employer MSK medical claims and ROI study

Past research about Hinge Health focused on clinical outcomes. Two randomized controlled trials demonstrated Hinge Health's efficacy in improving–pain and function for chronic back pain and chronic knee pain (12–13). The program performed well at scale with Hinge Health's first 10,000 members, experiencing an average of 68% reduction in pain per participant, 58% reduction in depression scores, and 58% reductions in anxiety scores (14–15). In another large-scale clinical study, the program demonstrated long-term, 1-year sustained improvements in pain, depression, and anxiety (16).

Although evidence of the effectiveness of digital MSK programs with regard to clinical outcomes is growing, no large-scale studies have estimated changes in medical care costs and utilization produced by digital MSK programs. This study's primary objective was to estimate the impact of Hinge Health's chronic pain program on overall MSK costs. A secondary objective was to identify main drivers of overall cost savings by examining costs and utilization of specific service types.

Study objectives

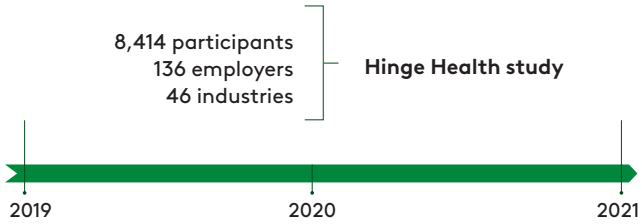
Estimate the impact of Hinge Health's chronic pain program on overall MSK costs

Identify main drivers of overall cost savings by examining costs and utilization of specific service types

Method

Study design

To achieve the study objectives, we conducted a longitudinal study comparing Hinge Health members' 12-month pre-to-post changes in medical care costs and utilization to those of a propensity score–matched, nonparticipant, control group.



Data source and variables

We used HIPAA-compliant, de-identified data files sourced from a large number of health plans and representing more than 100 million commercially insured lives from January 1, 2016, through September 30, 2021, across all US states and territories.

We acquired all claims data for Hinge Health members enrolled in the chronic pain program and a sample of 5 million commercially insured lives randomly drawn from the broader population in the same date range mentioned above. Data with enrollment dates and dates of service between January 2019 and September 2021 were included in this study.

Objective 1:

Overall MSK-specific costs

For the primary study objective concerning overall MSK costs, we used the allowed amount to estimate per-member-per-year (PMPY) costs for all MSK-related claims in the 12-month baseline and the 12-month post periods. ("Sample selection and matching" below further explains baseline and post periods.) An MSK-related claim was identified using the principal ICD-10 diagnosis code on a claim (Appendix 1).

Objective 2:

Cost and utilization of specific service types

For our secondary objective concerning drivers of savings, we examined cost and utilization of the following service types: surgery, injection, emergency department visit, other invasive procedures (e.g., vertebroplasty), provider evaluation and management (E&M) services in any setting, physical or occupational therapy, imaging, durable medical equipment (DME) utilization, tests (e.g., laboratory), and all other treatments.

First, we applied the Restructured Berenson-Eggers Type of Service Classification System (RBCS) to categorize similar current procedural terminology or healthcare common procedure codes together. Second, we categorized services at the claim level based on service intensity if multiple services were included on one claim (Appendix 2). For example, a single claim that included codes for a surgery, imaging, provider E&M services, and tests was categorized as a surgical claim. Then for cost, we aggregated allowed amounts in the baseline and post periods by service type. For utilization, we determined whether a person received the service type in the baseline and post periods.

Demographics and comorbidities

The data set included the following demographic information: (1) age groups (18–29, 30–39, 40–49, 50–64 at the time of the data extraction), (2) gender, and (3) nine census divisions (based on the most recent enrollment file). To determine the presence of comorbidities, we applied the Agency for Healthcare Research and Quality's Clinical Classifications Software Refined (CCSR) taxonomy to primary ICD-10 diagnosis codes in the claims data. Specifically, we included 11 comorbidities: hypertension, heart disease, diabetes, obesity, mental health, substance use, autoimmune conditions, neurological issues, respiratory issues, HIV, and osteomyelitis (Appendix 3).

Sample selection and matching

Sample

We grouped Hinge Health and control group members by specific pain region and by the month and year when members started Hinge Health and the control group had an index event (i.e., physical or occupational therapy or provider E&M visit for back, knee, shoulder, hip, or neck pain). For example, Hinge Health members who started the back program in January 2020 were grouped with control group members with a back-related index event in January 2020. Then, we applied the remaining inclusion and exclusion criteria shown in Table 1.

Table 1:
Inclusion and exclusion criteria

	Hinge Health group	Control group
Inclusion criteria	• 18–64 years old • Completed at least one exercise session or accessed one educational article in the chronic pain program for back, knee, shoulder, hip, or neck pain between January 2020 and October 2020	• 18–64 years old • Had a physical or occupational therapy or provider E&M visit for back, knee, shoulder, hip, or neck pain in January 2020 through October 2020
	Continuously enrolled in a health plan 12 months before and after starting Hinge Health/index event	
	Had at least one nonsurgical, MSK-specific medical care claim in the 12 months before starting the Hinge Health chronic program or before the index event	
Exclusion criteria	• Cancer or pregnancy diagnosis code (Appendix 4) between January 2019 and September 2021 • Missing demographic data • Total chronic MSK cost is over $300,000 or total medical spend is over $1 million in either the pre or post period	
Sample size (before matching)	*n* = 4,207	*n* = 256,290

Matching

The Hinge Health and control groups meeting the above criteria differed on baseline characteristics (Appendix 5). Thus, we conducted the following propensity score–based matching procedures, stratified by pain region.

01

First we calculated a propensity score for each individual using a logit model with the following covariates: demographics (age group, gender, census division), month of Hinge Health start or index event, comorbidities at baseline, total baseline non-MSK medical cost quantile, total baseline MSK costs, baseline cost quantiles for specific MSK services (injection, other invasive procedures, physical or occupational therapy, imaging), baseline emergency department utilization, and baseline other treatment utilization.

02

Next, we matched control group members to Hinge Health members on propensity score, using full Mahalanobis matching with 1:1 nearest neighbor without replacement. Matching was conducted separately for each pain region (i.e., back, knee, shoulder, hip, neck).

03

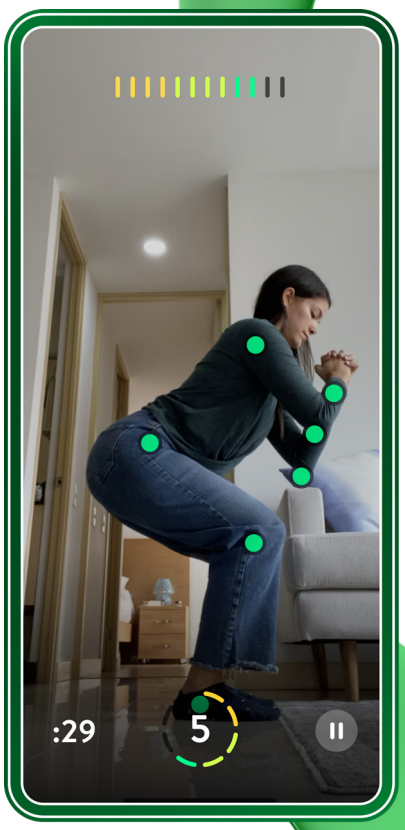
The final analytic sample included 4,207 Hinge Health members and 4,207 matched control members (Appendix 6). After matching, the Hinge Health group and matched control group did not exhibit any significant differences in baseline demographics, clinical characteristics, medical care utilization, or costs (chi-square tests, $p<0.01$, Appendix 7).

Analysis

For our primary study objective, we calculated baseline and post-period overall MSK costs. Baseline and post periods were the 12 months before and after the month of starting Hinge Health or index event. A two-sample t-test was conducted to evaluate post-period differences in cost between groups. A two-sided, $p<0.01$ threshold indicated statistical significance. Then, we calculated the change in cost for Hinge Health members and the control group (change equals post-period cost minus baseline cost). Next, we calculated savings using a difference-in-differences method, or the control group's change minus the Hinge Health group's change. Finally, we calculated the ROI as the savings divided by $995.

We calculated the baseline, post-period, change, and difference-in-differences estimates for service-specific costs and utilization for the secondary study objective.

We used Stata statistical software version 17.0 to conduct the analyses. Data analysis was performed in June 2022.



Results

Baseline characteristics

Over half (53%) of the people in the Hinge Health and control groups were female, and over 60% were in the 50–64 age group. Geographically, study participants lived in all nine census divisions, with the most in the Pacific (28%). The top three comorbidities were mental health (19%), hypertension (18%), and heart disease (9%). Average per-member, all-cause medical care costs were $7,659 for the control group and $7,339 for the Hinge Health group in the 12-month baseline period (p=0.413). Chronic MSK care was 20% of total medical care costs for both the control group and the Hinge Health group.

Overall MSK costs

Figure 1 shows that **the Hinge Health chronic pain program produced a 2.4x ROI with $2,387 of medical claims reduction per Hinge Health participant per year compared to the control group.** The average overall MSK cost increased $484, from $1,486 to $1,970, in the Hinge Health group, and increased $2,871, from $1,512 to $4,383, in the control group.

Clinical outcomes

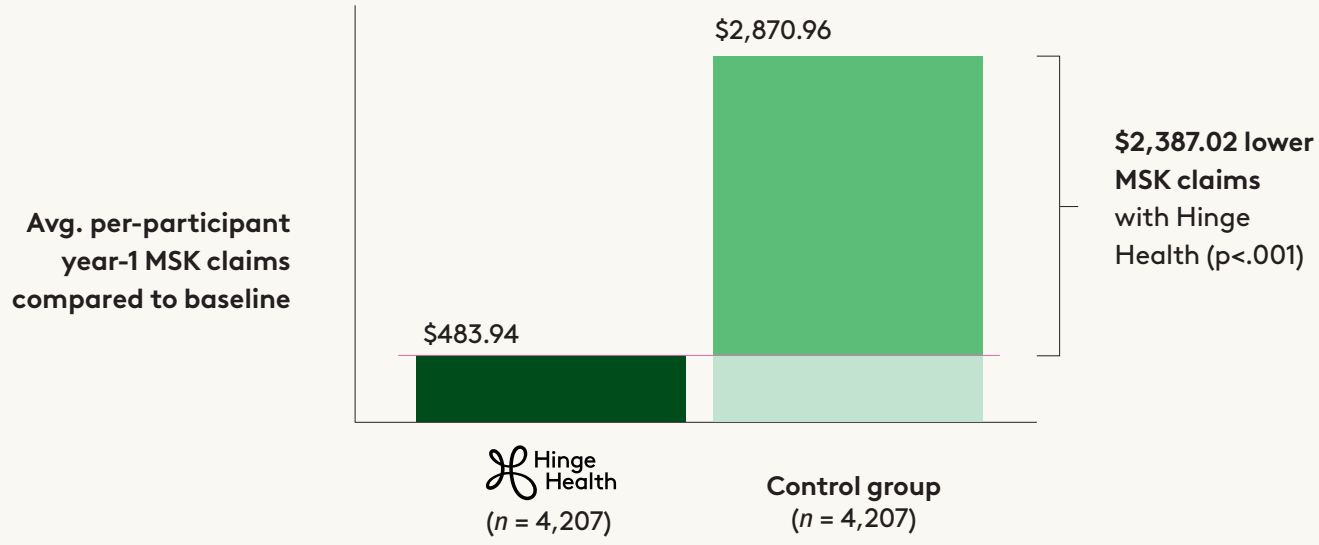
2.4x

ROI

$2,387

average savings
annual medical claims reduction per Hinge Health participant, compared to control group

Figure 1
Hinge Health reduced total MSK claims $2,387.02 per participant

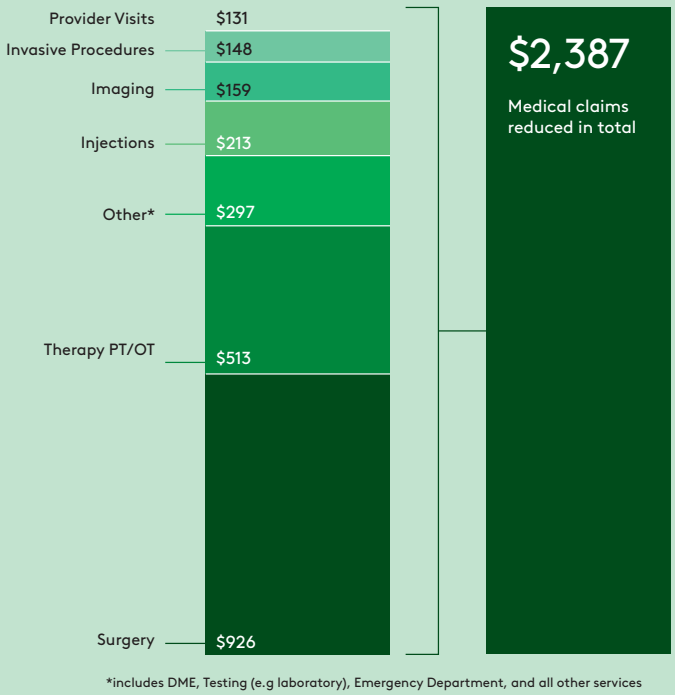


39% medical claims reduction in surgeries

We examined cost and utilization of specific service types to better understand how Hinge Health achieved lower overall costs.

Table 2 shows the amount saved for each service type. **Of the $2,387 savings (described above), $926 (39%) was from lower surgery costs,** $513 (21%) was from lower physical or occupational therapy costs, and $213 (9%) was from lower injection costs.

Savings per member by service type



*includes DME, Testing (e.g laboratory), Emergency Department, and all other services

Table 2
Medical claims reduction by service type

Service types	A Change from year 1 to baseline, control group	B Change from year 1 to baseline, Hinge Health group	C Total saved with Hinge Health (A-B)	D Percent savings with Hinge Health (C/$2,387)
Surgery	$1,729.33	$803.62	$925.71	38.78%
Physical or occupational therapy	$369.77	-$143.26	$513.03	21.49%
Injection	$185.06	-$27.68	$212.74	8.91%
Imaging	$72.16	-$86.36	$158.52	6.64%
Other invasive service (e.g., vertebroplasty)	$134.54	-$13.32	$147.86	6.19%
Provider E&M (physician or provider visit)	$95.58	-$35.00	$130.58	5.47%
DME	$163.20	$46.47	$116.73	4.89%
Testing (e.g., laboratory)	$12.50	$1.12	$11.38	0.48%
Emergency department	$1.44	-$4.17	$5.61	0.24%
Totals			**$2,222.16**	

Change in utilization of specific service types

We examined changes in the percentage of each group using specific service types (Table 3). The service types with the most difference between Hinge Health and control groups were imaging, injections, DME, and surgery. For example, Hinge Health was associated with 11% fewer people getting imaging versus the control group.

Drivers of reduced MSK service use

- Surgery
- DME
- Injections
- Imaging

Table 3
Change in utilization of services

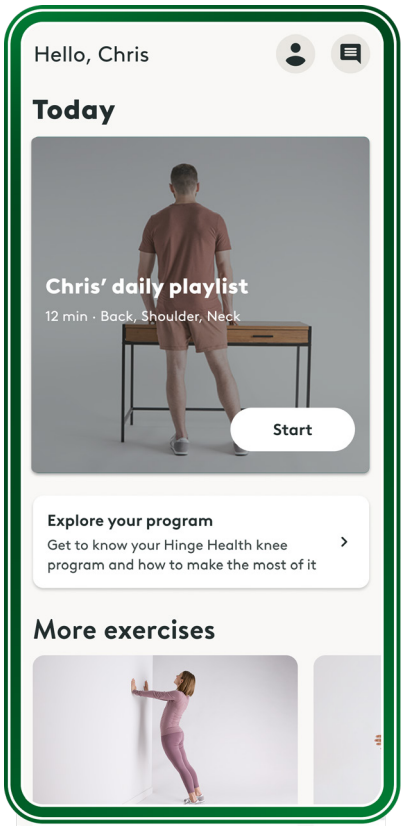
Service types	A Change from year 1 to baseline, control group	B Change from year 1 to baseline, Hinge Health group	C Reduction in percent with service utilization with Hinge Health (A-B)
Imaging	-7.61%	-18.97%	11.36%
Injection	3.02%	-4.32%	7.34%
DME	6.73%	2.59%	4.14%
Surgery	7.58%	3.61%	3.97%
Testing (e.g., laboratory)	1.78%	-1.54%	3.32%
Other invasive service (e.g., vertebroplasty)	2.02%	-1.00%	3.02%
Emergency department	0.05%	-1.09%	1.14%

Table note. We exclude PT/OT and provider E&M from this analysis because the control group had PT/OT and provider E&M index events in the post period by definition.

Discussion

This large-scale, empirical study found that cost savings for the Hinge Health group from 136 employers was $2,387, which is 2.4 times more than the $995 program cost. The Hinge Health group had statistically significantly lower MSK costs in the 12-month post period versus the control group. Leveraging a well-curated medical claims database, this study of N =8,414 participants offered real-world evidence of the impact of a digital chronic MSK pain program on medical care cost and utilization in a large population. We applied a propensity score–matching method based on an extensive list of baseline covariates to construct a statistically comparable nonparticipant control group. As a result, we were better able to compare the two groups and account for baseline characteristics that could have affected outcomes.

This study applied a difference-in-differences framework to account for unobserved confounders, such as external social and public health events that may have affected medical care cost and utilization patterns. Specifically, the study period spanned 2019 to 2021, when the COVID-19 pandemic significantly curbed the utilization of many elective medical care services. Comparing pre to post changes in outcomes for both groups helped to minimize the effects of the pandemic on results.



Nevertheless, a decrease in elective surgeries during the pandemic may have limited the potential of the Hinge Health program to avoid further surgeries.

Analysis results were most generalizable to Hinge Health members with specific characteristics. First, members, aged 18 to 64 years, were covered by an employer-sponsored health plan that contributed to the data repository. Second, members had 24 months of continuous enrollment in their health plan. Third, members utilized nonsurgical medical care for MSK needs in the 12 months before starting Hinge Health or having an index event (physical therapy or provider E&M service). However, we did explore how study results changed when we included members who utilized any medical care for MSK needs (including surgery) at baseline. We observed that savings increased to $2,752 (ROI: 2.8x), with 60% of savings coming from lower surgery costs (Appendix 8).

The study may have omitted important confounding variables that attenuated outcomes estimates. For example, the data did not contain geographic information smaller than census division. As a result, we were unable to mitigate the effect of geographically related community factors (e.g., education, income) and medical cost variation. However, as a robustness check, we examined medical care utilization and found that reductions in care utilization were consistent with observed reductions in costs. Other omitted variables were health plan structure and other benefits programs offered concurrently by employers. Generous policies and benefit programs were likely to have influenced Hinge Health participation and MSK medical care utilization and cost.

Findings from this study examined several MSK chronic pain regions together. However, the medical care journey for members with chronic back pain may differ from those with chronic hip pain considering joint replacement surgery. Future studies with more detailed views of medical care utilization for specific conditions are planned. Furthermore, the Hinge Health Digital Clinic now covers the full continuum of MSK care needs, including acute pain, chronic pain, expert medical opinion, and surgery rehabilitation. Future studies covering cost savings for the Hinge Health Digital Clinic as a whole are also planned.

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Hinge Health chronic MSK medical claims reduction

$2,387

medical claims reductions per Hinge Health participant

2.4x

ROI delivered per Hinge Health participant

Conclusion

In conclusion, **using a method independently reviewed by a global leader in actuarial science, this 2022 study found that the Hinge Health chronic pain program produced statistically significant savings and a 2.4x ROI among those who recently received in-person, nonsurgical care for their MSK conditions.** The Hinge Health program helps employers and payers avoid costs from MSK medical claims, especially from elective surgeries. Study results can help guide employers and payers making decisions about benefits offerings that most effectively manage rising MSK costs.

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Appendices

Appendix 1
MSK diagnosis codes included in the analysis to identify MSK-specific medical claims

Appendix 2
Claim-level service cost categorization hierarchy

Appendix 3
MSK-related comorbidities

Appendix 4
Exclusion criteria

Appendix 5
Baseline characteristics of unmatched cohorts

Appendix 6
Sample selection flow chart

Appendix 7
Baseline characteristics of matched cohorts

Appendix 8
Additional analyses among the Hinge Health and control groups with any care for MSK needs at baseline

Appendix 1

MSK diagnosis codes included in the analysis to identify MSK-specific medical claims

G5700, G5701, G5702, M12011, M12012, M12019, M12051, M12052, M12059, M12061, M12062, M12069, M12111, M12112, M12119, M12151, M12152, M12159, M12161, M12162, M12169, M1218, M12211, M12212, M12219, M12251, M12252, M12259, M12261, M12262, M12269, M12311, M12312, M12319, M12351, M12352, M12359, M12361, M12362, M12369, M12411, M12412, M12419, M12451, M12452, M12459, M12461, M12462, M12469, M12511, M12512, M12519, M12551, M12552, M12559, M12561, M12562, M12569, M12811, M12812, M12819, M12851, M12852, M12859, M12861, M12862, M12869, M13111, M13112, M13119, M13151, M13152, M13159, M13161, M13162, M13169, M13811, M13812, M13819, M13851, M13852, M13859, M13861, M13862, M13869, M14611, M14612, M14619, M14651, M14652, M14659, M14661, M14662, M14669, M1468, M14811, M14812, M14819, M14851, M14852, M14859, M14861, M14862, M14869, M1488, M160, M1610, M1611, M1612, M162, M1630, M1631, M1632, M164, M1650, M1651, M1652, M166, M167, M169, M170, M1710, M1711, M1712, M172, M1730, M1731, M1732, M174, M175, 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Appendix 2

Claim-level service cost categorization hierarchy

Category	Service type	Rules
Category 1: Emergency department visit	Emergency department visit	Highest priority: if the place of service code on a medical claim is 23 (hospital ED visit)
Category 2: Surgical and other invasive medical procedures	Surgery	If the prior categorical condition is not met, a medical claim is defined as a surgery if it includes a surgical RBCS category • RBCS surgery categories include arthrodesis–spine, arthroplasty–hip/knee, arthroscopy–lower/upper extremity, laminotomy or laminectomy–lumbar, and neurostimulator–back In cases when an RBCS category is not available (mostly facility claims), a surgery claim is defined by • ICD-10 procedure surgical inpatient category (facility claim) • DRG surgical inpatient category (facility claim) • Revenue center code surgical category (facility claim)
	Injections	If the above categorical conditions are not met, a medical claim is defined as an injection if it includes an injection RBCS category (AND does not include any surgery) • This category includes joint injections, nerve block injections, destruction by neurolytic agent, and hyaluronan injections
	Other invasive medical procedures	Given the previous categorical conditions are not met, a medical claim is defined as another invasive medical procedure if it includes a procedure RBCS category (AND does not include any surgery or injection) In cases when an RBCS category is not available (mostly facility claims), an invasive medical procedure claim is defined using the following criteria: • It has an ICD-10 procedure nonsurgical inpatient code OR DRG nonsurgical code • It does not have any of the facility-based surgery category codes (i.e., ICD-10 procedure, DRG, revenue center codes) • It includes an anesthesia claim

Category	Service type	Rules
Category 3: Therapy services	PT/OT therapy	If the previous categorical conditions are not met, a claim with a PT/OT RBCS treatment category code OR a facility PT revenue center code will be classified as a PT/OT therapy visit.
	Other therapies	Other RBCS treatment categories include chiropractic/ spinal manipulation and non-MSK-specific services such as non-oncological injections, cardiac rehabilitation, etc.
Category 3: Imaging service	Imaging	If the above categorical conditions are not met, a claim with an RBCS imaging service category will be defined as an imaging service encounter.
Category 4: Test	Test	If the previous categorical conditions are not met, a claim with an RBCS test category is defined as a test service encounter.
Category 5: Evaluation	Evaluation and management	If the above categorical conditions are not met, a claim with an RBCS evaluation and management category is defined as an EM service.
Category 6: DME	DME	An RBCS DME claim that does not include any of the above service types on the same claim.
Category 7: Uncategorized	Uncategorized	A claim that does not contain any of the above RBCS categories.

Note. **The RBCS procedure category** usually refers to a set of services performed at a single time and place, and it may include other services such as imaging and biopsy. We further categorize this service type into the following three types: (1) surgeries, such as arthrodesis spine, arthroplasty, arthroscopy, laminotomy or laminectomy, neurostimulator; (2) injections such as joint injection, nerve block injection, and destruction by neurolytic agent); and (3) other invasive MSK-specific medical procedures such as percutaneous vertebroplasty. **The RBCS treatment category** includes a set of medical interventions that are intended to be delivered repeatedly as part of a series over time, which could include E&M services. In addition to PT/OT treatment, there is also spinal manipulation (chiropractic care) and other non-MSK-specific services that reflect the treatment an individual received at the same time for other comorbidities (e.g., cardiac rehabilitation, vaccination, or other non-oncological injections such as monoclonal antibodies, anticoagulants, etc.).

Appendix 3
MSK- related comorbidities

MSK comorbidity	CCSR diagnosis codes
Cardiometabolic: hypertension	CIR007, CIR008
Cardiometabolic: heart	CIR0011, CIR012, CIR019
Cardiometabolic: diabetes	END002, END003
Obesity	END009
Mental health	FAC007, MBD001-MBD013, SYM008
Substance use	MBD017-MBD026, SYM009
Autoimmune	MUS003, MUS024, MUS025, MUS033, MUS034, MUS036
Neuro	NVS004, NVS005, NVS010
Respiratory	RSP008, RSP009
HIV	INF006
Osteomyelitis	MUS002

Appendix 4
Exclusion criteria

We excluded individuals who had any of the following CCSR diagnosis codes in the principal or secondary diagnosis code position on the facility claim or in the principal diagnosis codes on the professional claim after January 1, 2019:

Excluded conditions	CCSR diagnosis codes
Cancer, neoplasms	NEO001-NEO025, NEO028-NEO71
Certain conditions originating in the perinatal period	Any PNL code
Pregnancy, childbirth, and the puerperium	Any PRG code

Appendix 5

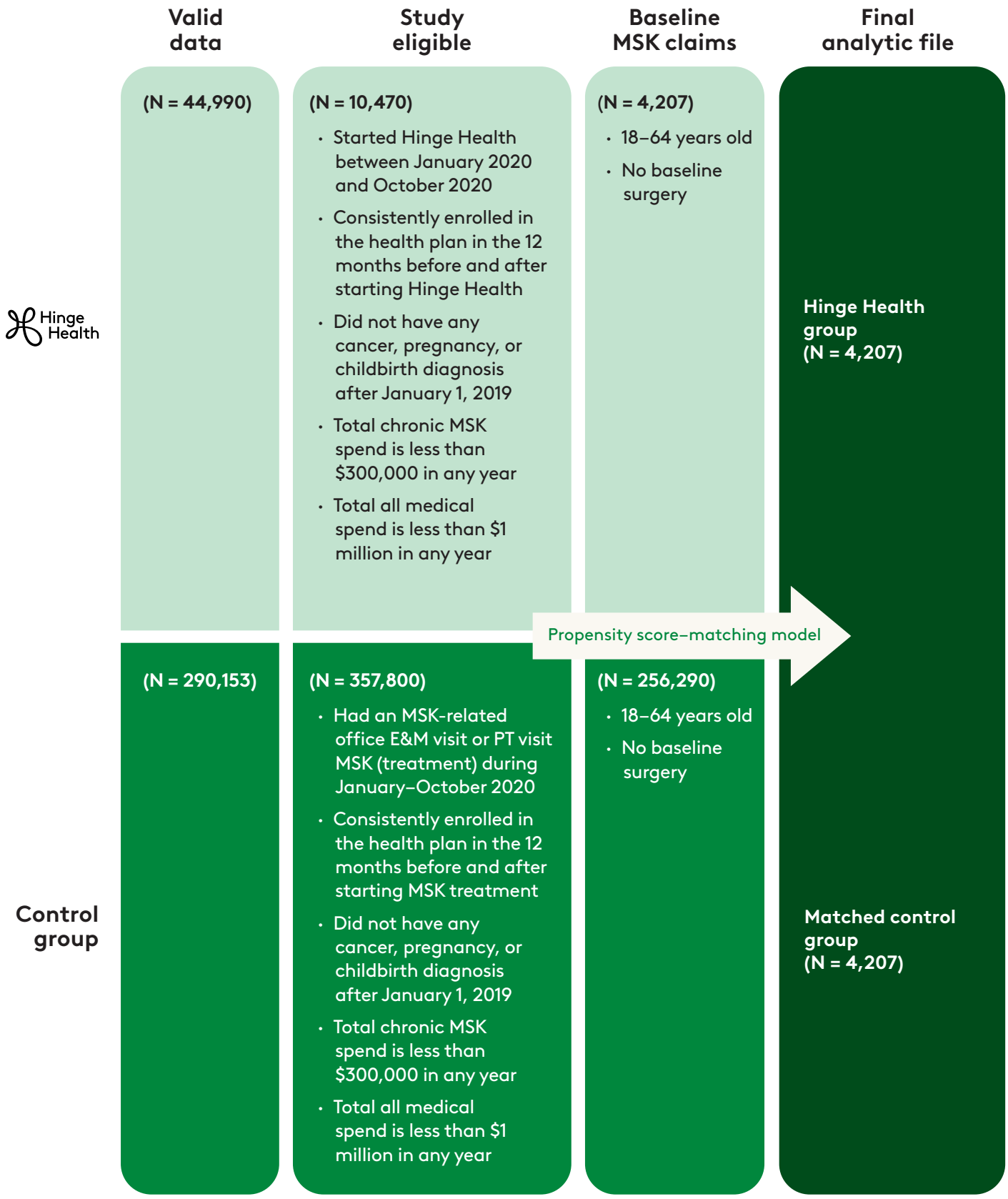
Baseline characteristics of unmatched cohorts

Variable	Control	HH	P-value
N	256,290	4,207	
Demographics (%)			
Female %	55.63	53.36	0.003
Male %	44.37	46.64	
18–29 %	11.10	1.43	<0.001
30–39 %	11.73	14.14	
40–49 %	24.22	23.70	
50–64 %	52.96	60.73	
New England %	4.57	2.19	<0.001
Middle Atlantic %	14.49	3.54	
East North Central %	22.00	19.06	
West North Central %	10.11	7.73	
South Atlantic %	15.27	15.40	
East South Central %	9.82	3.85	
West South Central %	10.76	12.03	
Mountain %	4.49	7.80	
Pacific %	8.46	28.41	
Comorbidity (%)	**Control**	**HH**	
Cardiometabolic: hypertension	16.29	17.71	0.014
Cardiometabolic: heart	8.46	8.22	0.581
Cardiometabolic: diabetes	7.43	8.20	0.060
Obesity	2.15	2.47	0.150
Mental health	19.53	19.28	0.681
Substance use	2.65	1.83	0.001
Autoimmune	2.24	2.52	0.231
Neuro	8.75	8.13	0.160
Respiratory	4.74	4.30	0.180
HIV	0.18	0.19	0.908
Osteomyelitis	0.12	0.07	0.344

Variable	Control	HH	P-value
12-mo pre-intervention spending & utilization			
All medical spending	$8,956.00	$7,339.02	<0.001
Chronic MSK spending	$2,283.21	$1,486.01	<0.001
Medical spending exl. chronic MSK (3 quantiles) %			
1st quantile	33.27	37.29	
2nd quantile	33.32	33.80	<0.001
3rd quantile	33.41	28.90	
Injection spending (3 quantiles) %			
1st quantile	83.53	81.91	
2nd quantile	0.00	0.00	0.005
3rd quantile	16.47	18.09	
Other invasive medical procedure spending (3 quantiles) %			
1st quantile	91.88	92.32	
2nd quantile	0.00	0.00	0.295
3rd quantile	8.12	7.68	
PT/OT therapy spending (3 quantiles) %			
1st quantile	43.26	48.11	
2nd quantile	23.24	28.55	<0.001
3rd quantile	33.50	23.34	
E&M (office and other) spending (3 quantiles) %			
1st quantile	59.12	53.22	
2nd quantile	8.97	20.04	<0.001
3rd quantile	31.91	26.74	
Imaging spending (3 quantiles) %			
1st quantile	64.75	57.78	
2nd quantile	4.86	8.94	<0.001
3rd quantile	30.39	33.28	
ED service utilization %	2.31	1.83	0.039
Other therapy service utilization %	43.57	28.86	<0.001

Appendix 6

Sample selection flow chart



Appendix 7

Baseline characteristics of matched cohorts

Variable	Control	HH	P-value
N	4,207	4,207	
Demographics (%)			
Female	53.32	53.36	0.0965
Male	46.68	46.64	
18–29	1.52	1.43	0.827
30–39	13.91	14.14	
40–49	24.48	23.70	
50–64	60.09	60.73	
New England	2.02	2.19	0.944
Middle Atlantic	3.30	3.54	
East North Central	19.32	19.06	
West North Central	7.42	7.73	
South Atlantic	14.88	15.40	
East South Central	3.80	3.85	
West South Central	12.95	12.03	
Mountain	7.92	7.80	
Pacific	28.38	28.41	
Comorbidity (%)	**Control**	**HH**	
Cardiometabolic: hypertension	18.02	17.71	0.711
Cardiometabolic: heart	9.13	8.22	0.141
Cardiometabolic: diabetes	8.30	8.20	0.874
Obesity	2.26	2.47	0.519
Mental health	20.04	19.28	0.380
Substance use	1.57	1.83	0.354
Autoimmune	2.66	2.52	0.681
Neuro	8.25	8.13	0.842
Respiratory	4.30	4.30	1.000
HIV	0.19	0.19	1.000
Osteomyelitis	0.14	0.07	0.317

Variable	Control	HH	P-value
12-mo pre-intervention spending & utilization			
All medical spending	$7,658.51	$7,339.02	0.413
Chronic MSK spending	$1,512.08	$1,486.01	0.613
Medical spending exl. chronic MSK (3 quantiles) %			
1st quantile	36.65	37.29	
2nd quantile	34.13	33.80	0.83
3rd quantile	29.21	28.90	
Injection spending (3 quantiles) %			
1st quantile	82.62	81.91	
2nd quantile	0.00	0.00	0.392
3rd quantile	17.38	18.09	
Other invasive medical procedure spending (3 quantiles) %			
1st quantile	91.75	92.32	
2nd quantile	0.00	0.00	0.334
3rd quantile	8.25	7.68	
PT/OT therapy spending (3 quantiles) %			
1st quantile	48.09	48.11	
2nd quantile	27.48	28.55	0.384
3rd quantile	24.44	23.34	
E&M (office and other) spending (3 quantiles) %			
1st quantile	52.56	53.22	
2nd quantile	20.23	20.04	0.823
3rd quantile	27.22	26.74	
Imaging spending (3 quantiles) %			
1st quantile	57.83	57.78	
2nd quantile	9.51	8.94	0.611
3rd quantile	32.66	33.28	
ED service utilization %	1.69	1.83	0.619
Other therapy service utilization %	28.45	28.86	0.682

Appendix 8

Additional analyses among the Hinge Health and control groups with any care for MSK needs at baseline

Table 8.1

Overall MSK costs at baseline and year 1

Overall MSK service cost	Service type	Rules
a. Baseline	$2,794.55	$2,803.92
b. Year 1 *	$4,877.96	$2,134.85
c. Change from year 1 to baseline (b minus a)	$2,083.41	-$669.07
d. Total MSK claims savings with Hinge Health (control group's change minus Hinge Health group's change)	$2,752	
e. Hinge Health return on investment (d / $995)	2.8x	

Table note. *indicates statistically significant difference between the Hinge Health and control groups.

Table 8.2

Savings for each service type

	A Change from year 1 to baseline, control group	B Change from year 1 to baseline, Hinge Health group	C Total saved with Hinge Health (A-B)	D Percentage of savings with Hinge Health (C/$2752)
Surgery	$1,457.56	-$183.77	$1,641.33	59.6%
Physical or occupational therapy	$287.40	-$183.22	$470.62	17.1%
Injection	$92.85	-$34.97	$127.82	4.6%
Other invasive service (e.g., vertebroplasty)	$64.78	-$42.48	$107.26	3.9%
Provider E&M	$62.14	-$44.08	$106.22	3.9%
Imaging	-$10.56	-$108.33	$97.77	3.6%
DME	$92.95	$0.61	$92.34	3.4%
Testing (e.g., laboratory)	$20.39	-$7.25	$27.64	1.0%
Emergency department	-$2.54	-$4.47	$1.93	0.1%

Hinge Health