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# The potential of a PROM-based DHI in knee and hip replacement to unburden the healthcare system post-surgery – Secondary analysis of the PROMoting Quality trial

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**PROM**oting  
Quality

From insight to impact.



# Background and objectives

- Global healthcare systems increasingly suffer from shortages of healthcare workers [1,2] and are under pressure from exploding healthcare costs [3]. Demographic change will worsen this situation [1,4,5].
- Digitalized PROM-based monitoring systems have the potential to improve mid-to-long-term outcomes, and in turn decrease follow-up treatments and costs
- While effectiveness of these tools has been shown to improve outcomes [6] and decrease healthcare utilization [7,8] for cancer care, it is unknown for other indications.

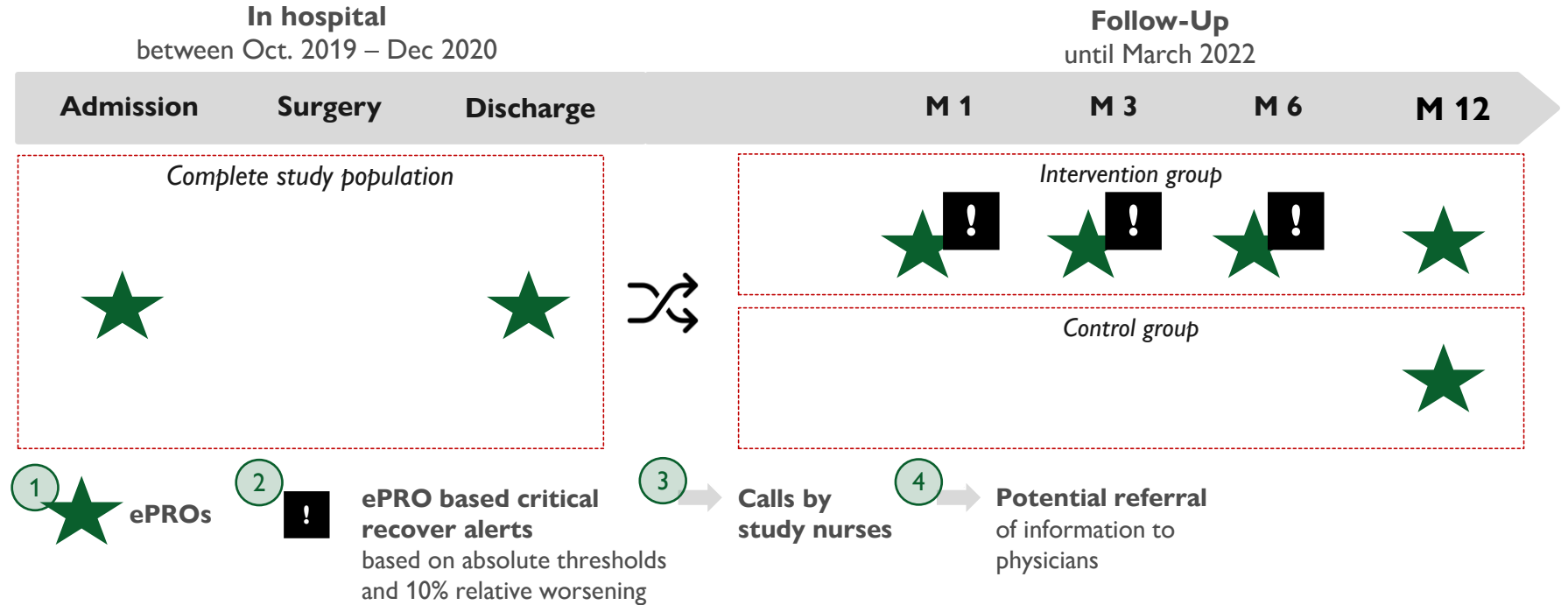
Our research aims at answering the following question:

**“Can a digital PROM monitoring and alert system for hip and knee replacement patients be used to decrease post-surgery health expenditures?”**



Secondary outcome of the PROMoting Quality trial

# Data & methods | The PROMoting Quality study design [9]



Sources: [9] Kuklinski et al. (2020)

# Data & methods | Sample generation and data sources

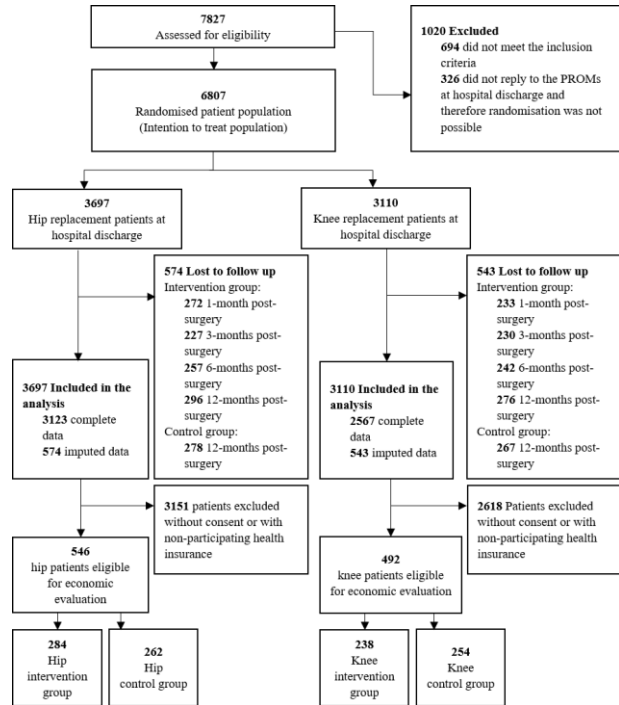


Figure 1: Trial Profile

- Between October 2019 and December 2020, 7827 patients were recruited from nine hospitals across Germany
- 3697 hip patients and 3110 knee patients were eligible and randomized
- Cost data available for 546 hip replacement patients and 492 knee replacement patients



# PROMoting Quality | Results on outcomes already published

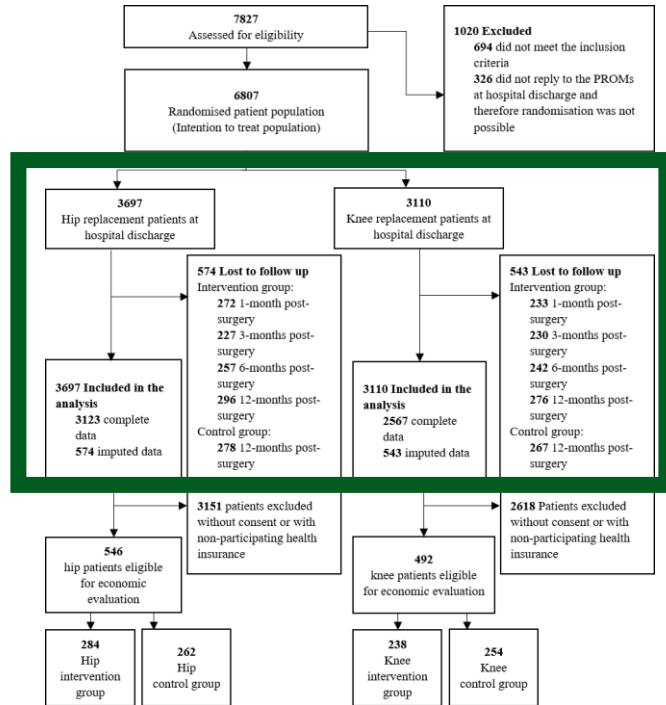


Figure 1: Trial Profile

Sources: [10] Steinbeck et al. (2023)

**JAMA Network | Open™**

Original Investigation | Orthopedics

September 1, 2023

## Electronic Patient-Reported Outcome Monitoring to Improve Quality of Life After Joint Replacement

### Secondary Analysis of a Randomized Clinical Trial

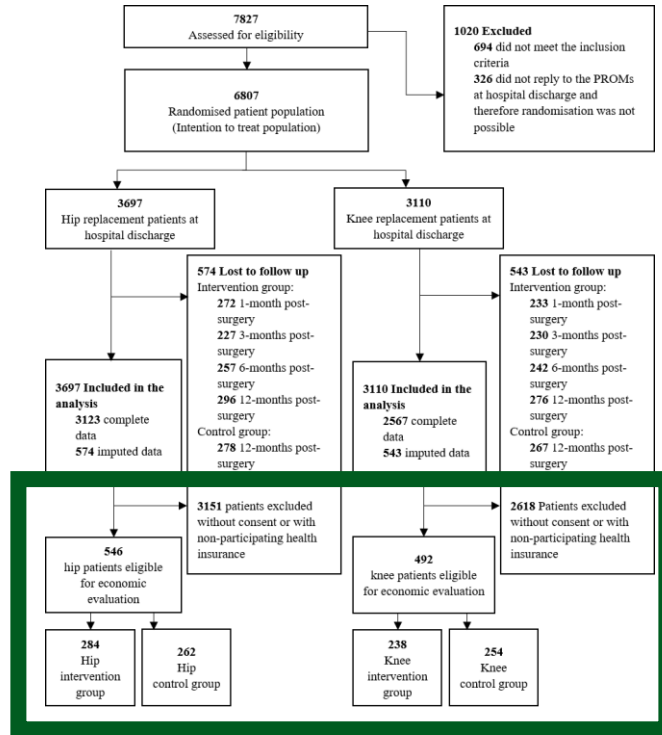
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# PROMoting Quality | Cost data for 546 hip and 492 knee replacement patients used



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- Cost data available for 546 hip replacement patients and 492 knee replacement patients

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- Costs and utilization directly associated with medical treatment
  - Health insurance claims data of 24 statutory health insurances (~22%)
  - Patient-level longitudinal cost data 1 year pre- and 1 year post-surgery
  - Data categorized in outpatient care (OC), inpatient care (IC), prescriptions (PRES), remedies (REM), medical aids (AIDS)

# Data & methods | Comparative analyses and mixed effect model used for statistical analysis



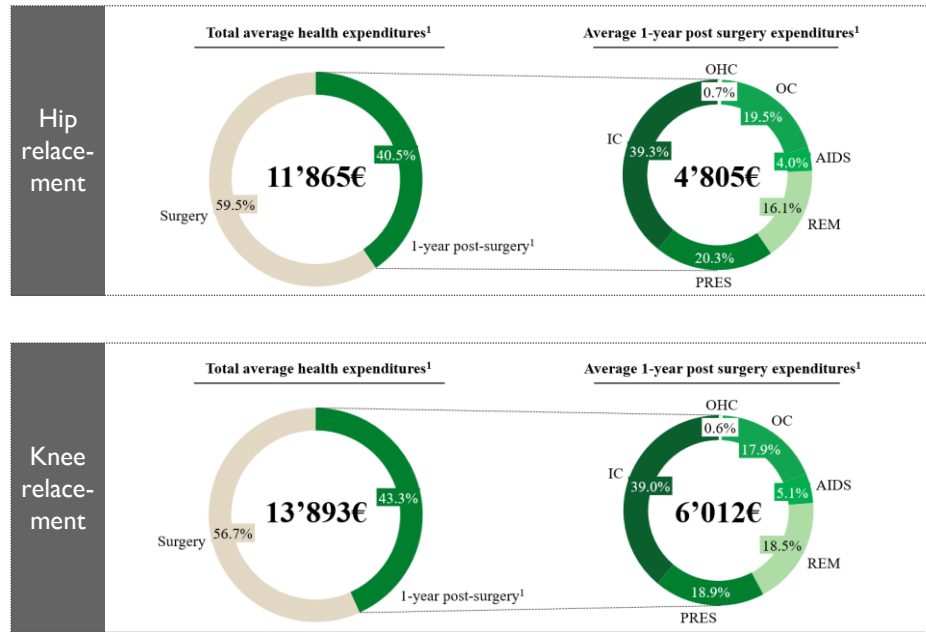
- **Comparative analysis:** use of t-tests and rank-sum tests to examine the intervention effect on post-surgery expenditures and utilization (e.g., physician visits)
- **Outliers:** To consider outliers and extreme costs we replaced the 5% extremest values in the dataset with values closest to the rest of the data by setting them to the minimum or maximum observed non-extreme values (winsorisation)
- **Cost data adjustments:** We adjusted the 1-year post-surgery cost data for pre-surgery differences between intervention and control group
- **Mixed effect model:** Testing for differences in the adjusted total post-surgery costs and utilization, as well as on the individual components: outpatient care, outpatient hospital care, inpatient care, prescriptions, remedies, and medical aids
  - Controlling for age, gender, post-surgery mobilization and BMI

# Results | Patients majorly female, around 66 years old, and mostly overweight – knee replacement with higher expenditures

## Baseline characteristics

	Hip (N=546)	Knee (N=492)
Age		
mean (SD)	66.3 (10.4)	65.7 (9.3)
Sex (%)		
Female	357 (65.4)	304 (61.8)
Male	189 (34.6)	188 (38.2)
BMI (%)		
Underweight	4 (0.7)	0 (0.0)
Normal	166 (30.4)	64 (12.0)
Overweight	197 (36.1)	167 (33.9)
Obese	179 (32.8)	261 (53.1)
Comorbidities (%)		
None	203 (37.2)	130 (26.4)
PROM baseline score means (SD)		
EQ-5D-5L	0.581 (0.255)	0.610 (0.244)
EQ-VAS	54.5 (18.8)	57.3 (18.5)
HOOS-/KOOS-PS	49.0 (16.0)	43.0 (11.2)
PROMIS-F-SF	48.6 (10.2)	48.0 (9.9)
PROMIS-D-SF	49.9 (8.3)	49.6 (8.6)
Pain Score	2.9 (1.4)	2.8 (1.3)

## Expenditure distribution



Notes: OC – Outpatient care; OHC – Outpatient hospital care; IC – Inpatient care; PRES – Prescriptions; REM – Remedies; AIDS – medical aids; 1. Expenditures include all health care expenditures occurred within 1-year post surgery excluding rehabilitation cost

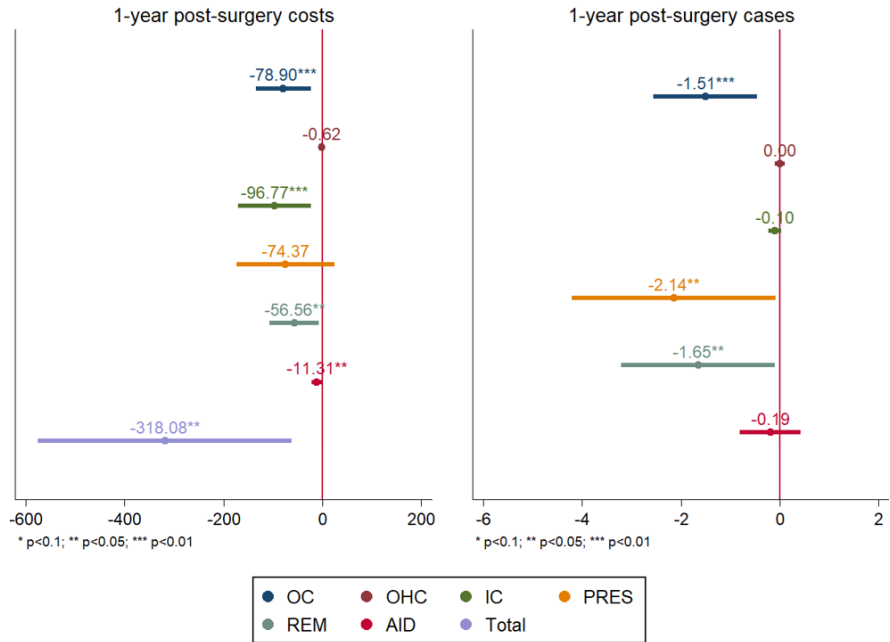


# Results – hip replacement | Comparative analyses shows differences for OC, IC, PRES and REM

		Intervention (n=284)				Control (n=262)				Comparative statistic <sup>a</sup>		
		mean	SD	median	IQR	mean	SD	median	IQR	Delta	p (t)	p (w)
OC	Utilisation n (%) <sup>b</sup>	284 (100.00%)				261 (99.62%)					0.298	0.298
	Cases <sup>c</sup>	11.91	5.96	11	7	13.51	6.83	13	9	-1.60	0.004	0.007
	Raw in € <sup>d</sup>	852.27	856.52	658.70	626.52	1026.72	1075.65	807.92	767.95	-174.45	0.036	0.003
	Adjusted in € <sup>e</sup>	816.43	329.89	740.13	422.10	907.01	360.41	817.18	539.86	-90.58	0.002	0.002
OHC	Utilisation n (%) <sup>b</sup>	21 (7.39%)				21 (8.02%)					0.786	0.786
	Cases <sup>c</sup>	0.15	0.63	0	0	0.15	0.61	0	0	0.01	0.853	0.823
	Raw in € <sup>d</sup>	32.00	145.72	0.00	0.00	40.29	217.47	0	0	-8.29	0.598	0.784
	Adjusted in € <sup>e</sup>	13.85	6.58	11.60	5.43	14.67	7.47	12.39	6.19	-0.82	0.174	0.240
IC	Utilisation n (%) <sup>b</sup>	74 (26.06%)				77 (29.39%)					0.385	0.385
	Cases <sup>c</sup>	0.36	0.71	0	1	0.46	0.84	0	1	-0.10	0.122	0.261
	Raw in € <sup>d</sup>	1735.18	4404.33	0.00	437.48	2055.79	4548.14	0.00	211.16	-320.61	0.403	0.352
	Adjusted in € <sup>e</sup>	1438.52	440.01	1332.25	541.30	1551.83	476.87	1403.10	714.14	-113.31	0.004	0.003
PRES	Utilisation n (%) <sup>b</sup>	272 (95.77%)				250 (95.42%)					0.840	0.840
	Cases <sup>c</sup>	14.05	12.69	11	14	16.52	14.20	14	16	-2.47	0.032	0.022
	Raw in € <sup>d</sup>	745.82	1775.37	280.56	649.58	1223.32	5054.07	364.97	690.06	-477.50	0.135	0.031
	Adjusted in € <sup>e</sup>	560.32	586.21	331.51	444.96	654.50	641.81	404.54	570.68	-94.18	0.074	0.023
REM	Utilisation n (%) <sup>b</sup>	239 (84.15%)				227 (86.64%)					0.413	0.412
	Cases <sup>c</sup>	8.36	8.58	6	8	10.09	10.01	8	11	-1.73	0.031	0.041
	Raw in € <sup>d</sup>	689.03	903.64	463.89	652.65	867.40	1217.52	563.37	843.16	-178.37	0.051	0.019
	Adjusted in € <sup>e</sup>	658.19	294.63	560.95	334.55	722.09	318.29	622.61	437.48	-63.90	0.015	0.010
AIDS	Utilisation n (%) <sup>b</sup>	175 (61.62%)				172 (65.65%)					0.329	0.329
	Cases <sup>c</sup>	2.36	3.64	1	3	2.66	4.01	1	3	-0.30	0.352	0.388
	Raw in € <sup>d</sup>	171.96	408.35	56.31	173.90	218.69	661.61	61.19	200.77	-46.73	0.317	0.320
	Adjusted in € <sup>e</sup>	132.82	64.35	112.75	63.71	146.47	67.95	124.89	80.65	-13.64	0.016	0.005
<b>Total</b>	Raw in € <sup>d</sup>	<b>4226.26</b>	<b>5575.47</b>	<b>2146.55</b>	<b>3946.5</b>	<b>5432.22</b>	<b>7604.43</b>	<b>2614.23</b>	<b>5918.04</b>	<b>-1205.96</b>	<b>0.034</b>	<b>0.019</b>
	Adjusted in € <sup>e</sup>	<b>3620.12</b>	<b>1544.80</b>	<b>3218.23</b>	<b>1619.8</b>	<b>3996.55</b>	<b>1656.16</b>	<b>3508.19</b>	<b>2312.27</b>	<b>-376.43</b>	<b>0.006</b>	<b>0.004</b>

OC – Outpatient care; OHC – Outpatient hospital care; IC – Inpatient care; PRES – Prescriptions; REM – Remedies; AIDS – medical aids; a: Comparative Analysis conducted at 5% level with two-sided t-tests (p(t)) and, in case of non-normality, with wilcoxon rank-sum tests (p(w)); b: if a service in the corresponding category was used at least once in the 1-year post-surgery period; c: number of cases per category in the 1-year post-surgery period; d: unadj. occurred costs the 1-year post-surgery period; e: 1-year post-surgery period costs adjusted for the baseline differences with winsorised linear regression

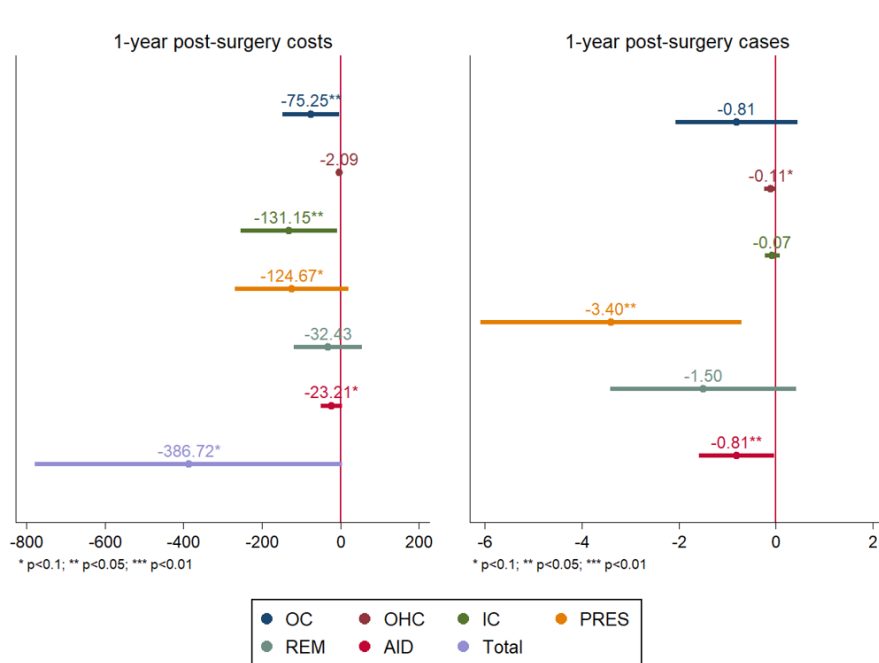
# Results – hip replacement | Mixed effect model results only slightly different – OC with most significant difference



- Total 1-year post-surgery expenditures are 318€ lower in the intervention than in the control group
- Significant effects wrt expenditures seen for OC, IC, REM, and AID
- Patients in the intervention group have 1,5 fewer outpatient physician visits than those in the control group
- Differences stem from GP visits (*ongoing analyses*)
- Differences in utilization and expenditures for remedies originate from physiotherapy sessions

Notes: OC – Outpatient care; OHC – Outpatient hospital care; IC – Inpatient care; PRES – Prescriptions; REM – Remedies; AIDS – medical aids; 1. Expenditures include all health care expenditures occurred within 1-year post surgery excluding rehabilitation cost

# Results – knee replacement: Effects of the intervention on expenditures and utilization weaker for knee than hip replacements



- Total 1-year post-surgery expenditures are 387€ lower in the intervention than in the control group (10% significance level)
- Significant effects wrt expenditures seen for OC, IC, PRES, and AID
- Only small and weakly significant effects on utilization (IC, AID)

Notes: OC – Outpatient care; OHC – Outpatient hospital care; IC – Inpatient care; PRES – Prescriptions; REM – Remedies; AID – medical aids; 1. Expenditures include all health care expenditures occurred within 1-year post surgery excluding rehabilitation cost



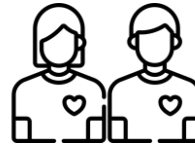
## Take aways



### “Can a digital PROM monitoring and alert system for hip and knee replacement patients be used to decrease post-surgery health expenditures?”

- Evidence that remotely monitoring hip and knee replacement 1-year post-surgery decreases healthcare utilization and expenditures (Hip: -318€<sup>\*\*</sup>; Knee: -386€<sup>\*</sup>)
- For hip replacement the intervention has significant positive effects on expenditures for nearly all cost categories – with strongest effects for OC (-78€<sup>\*\*\*</sup>), IC (-97€<sup>\*\*\*</sup>) and REM (-57€<sup>\*\*</sup>)
- Regarding utilization, we observe fewer OC physician visits (-1.51<sup>\*\*\*</sup>), prescriptions (-2.14<sup>\*\*</sup>), and remedies, esp. physiotherapy (-1.65<sup>\*\*\*</sup>)
- For knee replacement, effects are primarily for expenditures and less significant
- If implemented efficiently digital PROM applications could unburden the health systems budgets and counteract workforce shortages

# Acknowledgements



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**aQua**  
ZUKUNFT DURCH QUALITÄT

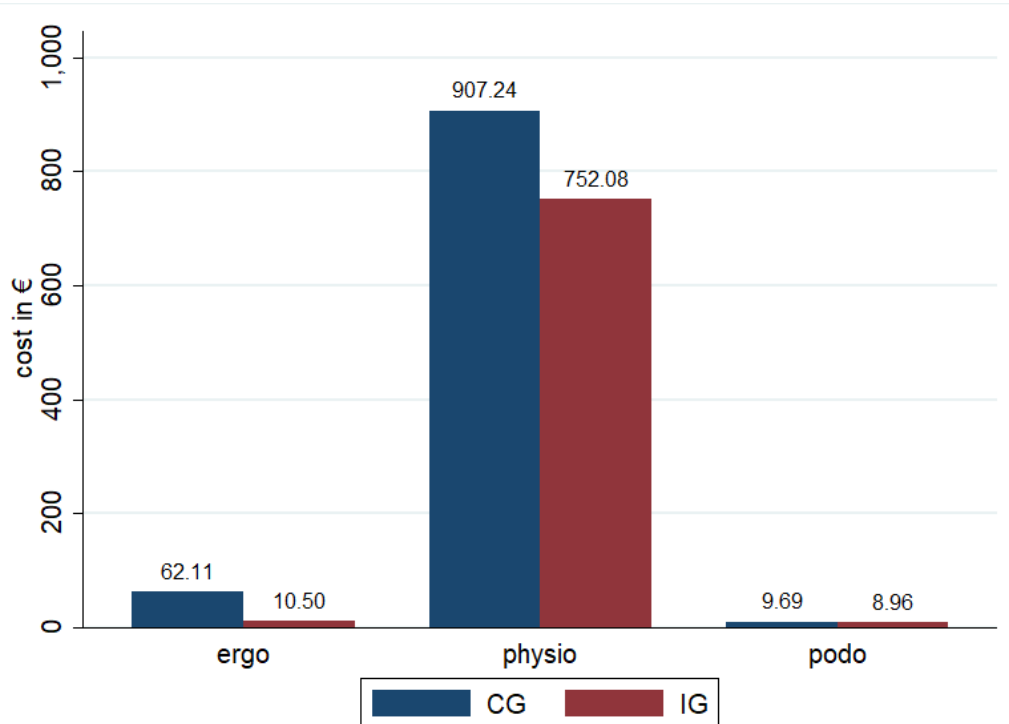
**heartbeat** 

# Sources – detailed

- [1] Zhang, X., Lin, D., Pforsich, H. & Lin, V. W. Physician workforce in the United States of America: forecasting nationwide shortages. *Hum Resour Health* 18, 8; 10.1186/s12960-020-0448-3 (2020).
- [2] Health and care workforce in Europe. Time to act (World Health Organization, Regional Office for Europe, Copenhagen, 2022).
- [3] Eurostat. Healthcare expenditure statistics. european Commission, 2023.
- [4] Statistisches Bundesamt. 15th Coordinated Population Projection for Germany. Variant 1: Moderate development in fertility and life expectancy and net migration, 2024.
- [5] Institute of Medicine (US) Committee on the Future Health Care Workforce for Older Americans. Health Status and Health Care Service Utilization. In *Retooling for an Aging America: Building the Health Care Workforce*, edited by Americans, Institute of Medicine Committee on the Future Health Care Workforce for Older (National Academies Press (US)2008).
- [6] Basch, E. et al. Overall Survival Results of a Trial Assessing Patient-Reported Outcomes for Symptom Monitoring During Routine Cancer Treatment. *JAMA* 318, 197–198; 10.1001/jama.2017.7156 (2017).
- [7] Riis, C. L. et al. Satisfaction with care and adherence to treatment when using patient reported outcomes to individualize follow-up care for women with early breast cancer - a pilot randomized controlled trial. *Acta oncologica (Stockholm, Sweden)* 59, 444–452; 10.1080/0284186X.2020.1717604 (2020).
- [8] Riis, C. L. et al. Satisfaction with care and adherence to treatment when using patient reported outcomes to individualize follow-up care for women with early breast cancer - a pilot randomized controlled trial. *Acta oncologica (Stockholm, Sweden)* 59, 444–452; 10.1080/0284186X.2020.1717604 (2020).
- [9] Kuklinski, D., Oschmann, L., Pross, C., Busse, R. & Geissler, A. The use of digitally collected patient-reported outcome measures for newly operated patients with total knee and hip replacements to improve post-treatment recovery: study protocol for a randomized controlled trial. *Trials* 21, 322; 10.1186/s13063-020-04252-y (2020).
- [10] Steinbeck, V. et al. Electronic Patient-Reported Outcome Monitoring to Improve Quality of Life After Joint Replacement: Secondary Analysis of a Randomized Clinical Trial. *JAMA network open* 6, e2331301; 10.1001/jamanetworkopen.2023.31301 (2023).

# Appendix

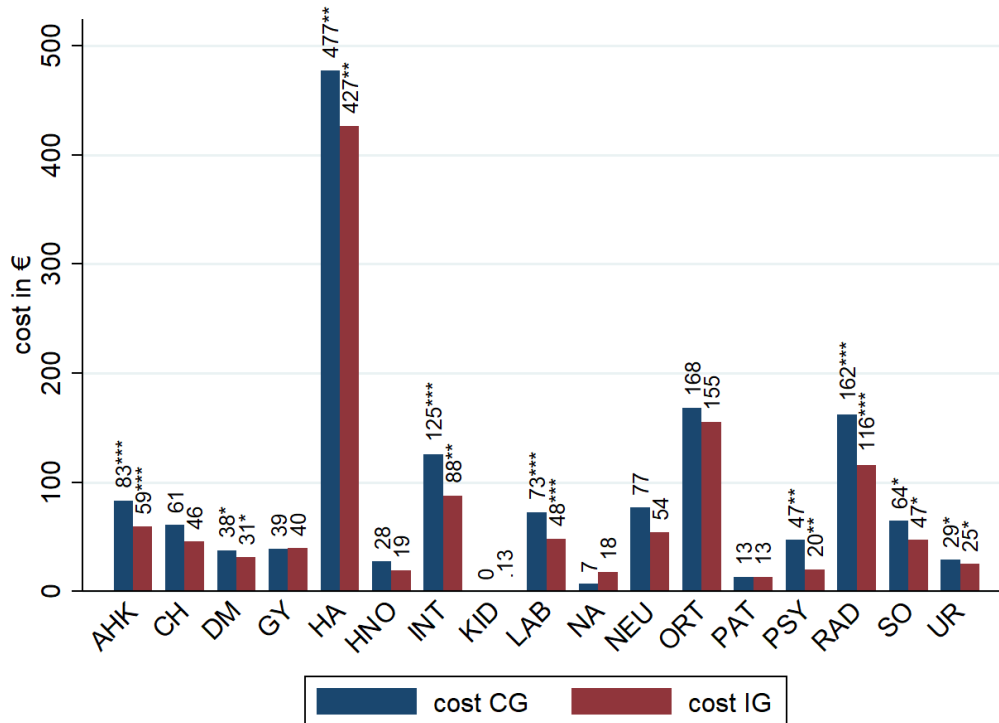
# Hip replacement patients – breakdown of REM expenditures 1-year post-surgery



- Hip replacement patients with major expenditure block in physiotherapy
- Within REM, the largest differences in cost between IG and CG are in physiotherapy



# Hip replacement patients – breakdown of OC expenditures 1-year post-surgery



abbrev	
AHK	Ophthalmology
CH	Surgeries
DM	Dermatology
GY	Gynecology
HA	GP
HNO	Ear, nose and throat specialist
INT	Internist
KID	Pediatrician
LAB	Laboratory medicine
NA	Unknown
NEU	Neurology
ORT	Orthopedics
PAT	Pathology
PSY	Psychotherapy
RAD	Radiology
SO	Other
UR	Urology

<https://www.barmer.de/resource/blob/1156100/e5c8425259ad58e177b7d5bbf6c8eef8/barmer-arztreport-2023-data.pdf>