HelmholtzZentrum münchen
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The Effect of Bariatric Surgery on Health Care Costs

A Synthetic Control Approach Using Bayesian Structural Time Series

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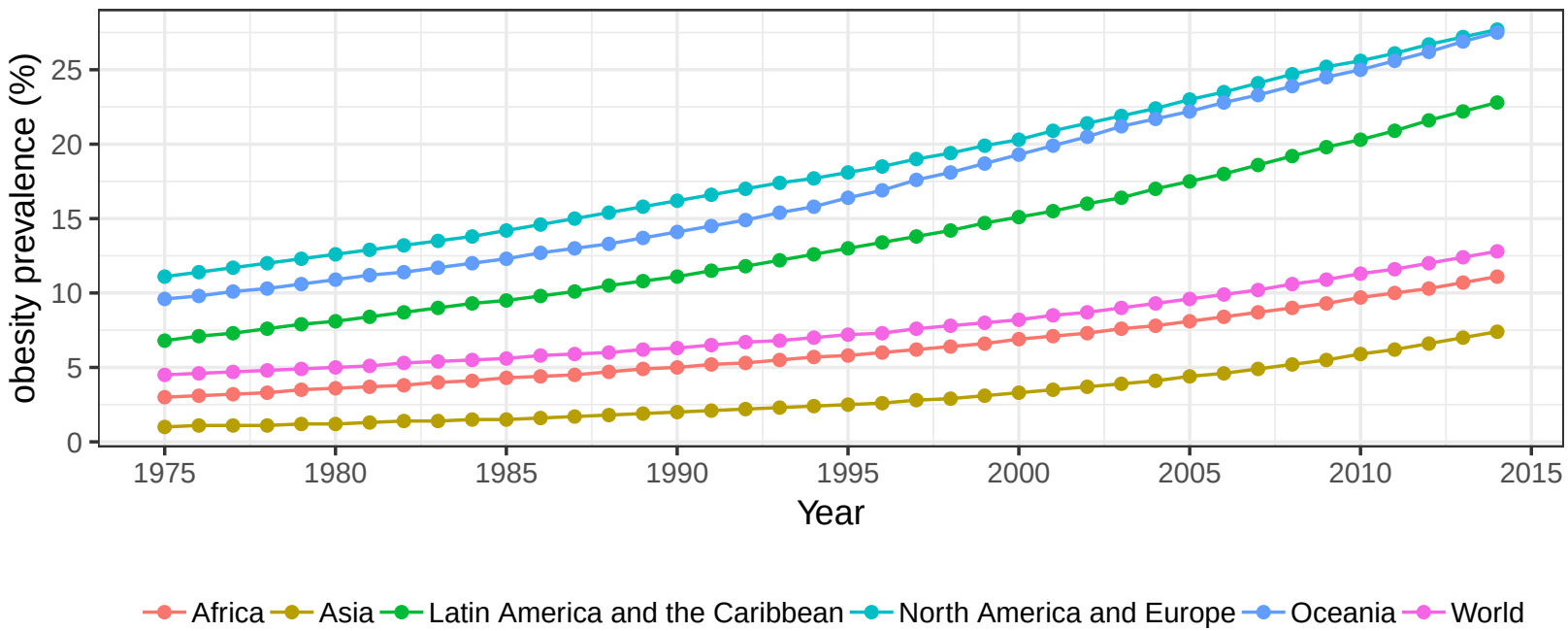
Overweight and obesity are a global public health concern

- If the current trends continue, by 2025, global obesity prevalence will reach 18% in men and surpass 21% in women.
- In Germany, approximately one in five 18 to 79 year olds have a body mass index (BMI) of at least 30 kg/m^2 (obese).
- People with obesity are at increased risk of type II diabetes mellitus, cardiovascular diseases and certain types of cancer.



Conservative treatment of obesity is often not effective

Conservative treatment methods like nutrition, physical activity, and behavioural therapy are often not effective for individuals with BMI > 35.

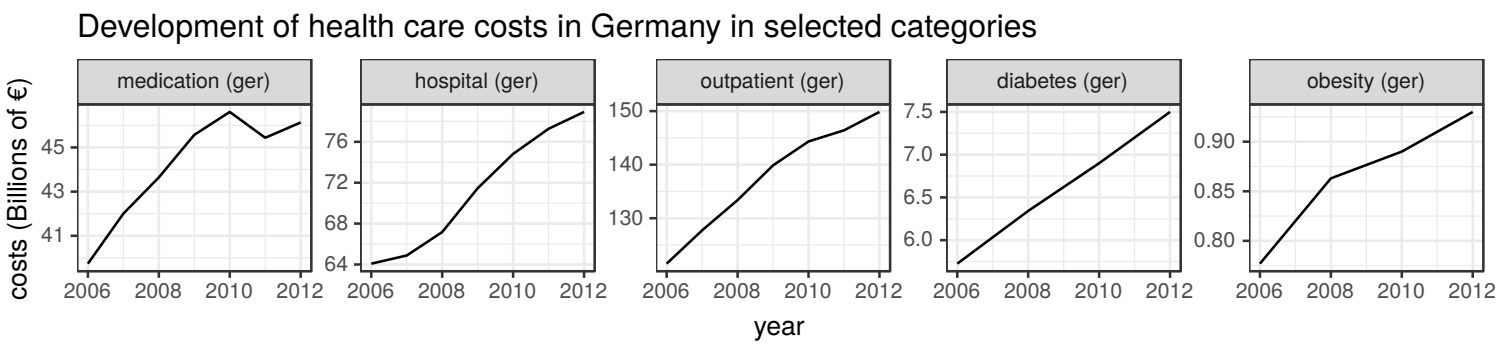
However, **surgical intervention** is more effective than conservative treatment with respect to reduction of body fat, improvement of obesity-associated diseases, and lowering mortality.

Gastric banding Gastric bypass Sleeve gastrectomy

image: www.pcornet.org

The economic aspects of bariatric surgery need to be considered

- High economic costs of obesity for health care providers
- Unclear long-term effects for health care utilization after bariatric surgery in the literature
- Bariatric surgery is currently not included in the standard benefit catalogue of statutory health insurance in Germany, but can be requested for individual cases
- The frequency of operations for morbid obesity is currently 9 per 100,000 adults in Germany; higher in other European countries (Sweden: 77; France: 57; Belgium: 108)



Is bariatric surgery cost-effective or even cost-saving in the long term?

We used AOK billing claims data

- AOK billing claims from 2005-2011 (quarterly)
- All individuals insured by AOK in Germany that received bariatric surgery (AOK covers ca. 30% of German population)
- $N = 2733$
- Mean age: 43.6 years
- Female: 73.3%
- outcome: medication, physician, and hospital costs
- To exclude utilization that is directly related to the intervention, we omitted the quarter immediately before and after surgery as well as the quarter of the surgery itself.

Estimating the causal effect of bariatric surgery on health care costs is difficult in this case

We only have cases, no controls

- no (propensity score) matching possible

We have time series data (quarterly) over many years

- Difference-in-Differences requires parallel trends
- Mixed models only account for averages before and after intervention
- ARIMA models cannot account for autocorrelation in the latent states

Solution: Bayesian structural time series model

Traditional synthetic control methods use a weighted combination of control time series

A number of time series that are **unaffected** by the intervention are optimally **weighted** according to their fit to the outcome in the pre-intervention period. They are then combined into a composite time series to which the treatment group is compared.

Examples:

Exposure	outcome	treated	donor pool
tax on cigarettes	Cigarette sales	California	other US states
trans fat ban	Heart disease mortality	Denmark	other OECD countries
pay for performance	Mortality	UK	other Europ. countries

more examples in: Bouttell et al., *J Epidemiol Community Health*, 2018

Bayesian structural time series are based on state space models

Bayesian structural time series (BSTS) are a forecasting method that uses other time series as covariates.

The BSTS model is based on a state space approach and defined as

$$\begin{aligned} Y_t &= \mu_t + x_t\beta + \varepsilon_t, & \varepsilon_t &\sim \mathcal{N}(0, \sigma_\varepsilon^2), \\ \mu_{t+1} &= \mu_t + \nu_t, & \nu_t &\sim \mathcal{N}(0, \sigma_\nu^2), \end{aligned}$$

Y_t: health care costs at time t
x_t: covariate time series
μ_t: local level term. This term defines how the latent state evolves over time (unobserved trend)
$x_t\beta$: "averages" over the selected covariate time series.

Bayesian structural time series are a variant of the synthetic control method

We can create a synthetic control series by **predicting the values for the post period** and then **compare to the actual values** to estimate the impact of the surgery. Posterior intervals can be created through sampling. We can also compute the tail probability of a non-zero impact.

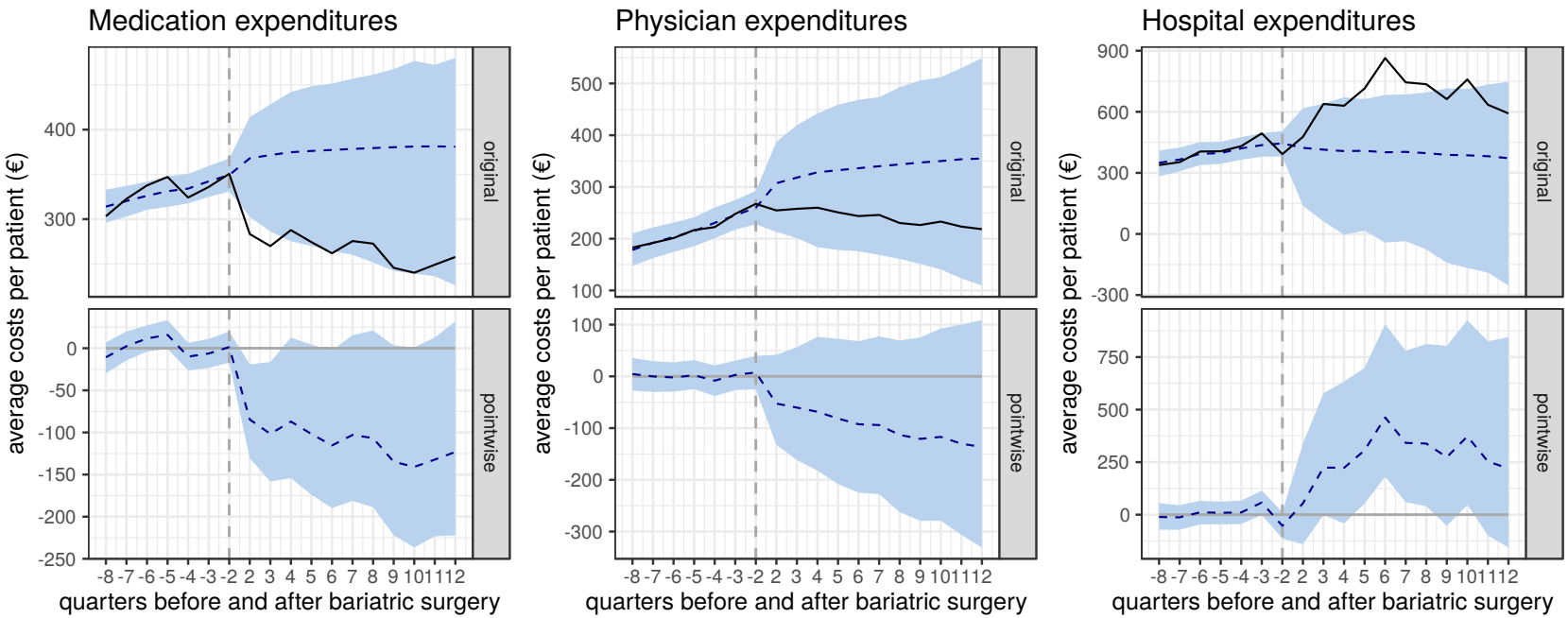
We use time series as covariates that are strongly correlated to health care costs, obesity, and diabetes:

- Costs of obesity over the years
- Costs of diabetes over the years
- health care costs of Germany in different categories (inpatient, outpatient, ...)

BSTS has a variable selection component (spike-and-slab prior) to automatically prune irrelevant covariates out of the model.

What would average costs be, if individuals had not received bariatric surgery?

We forecast counterfactual costs based on pre-intervention data



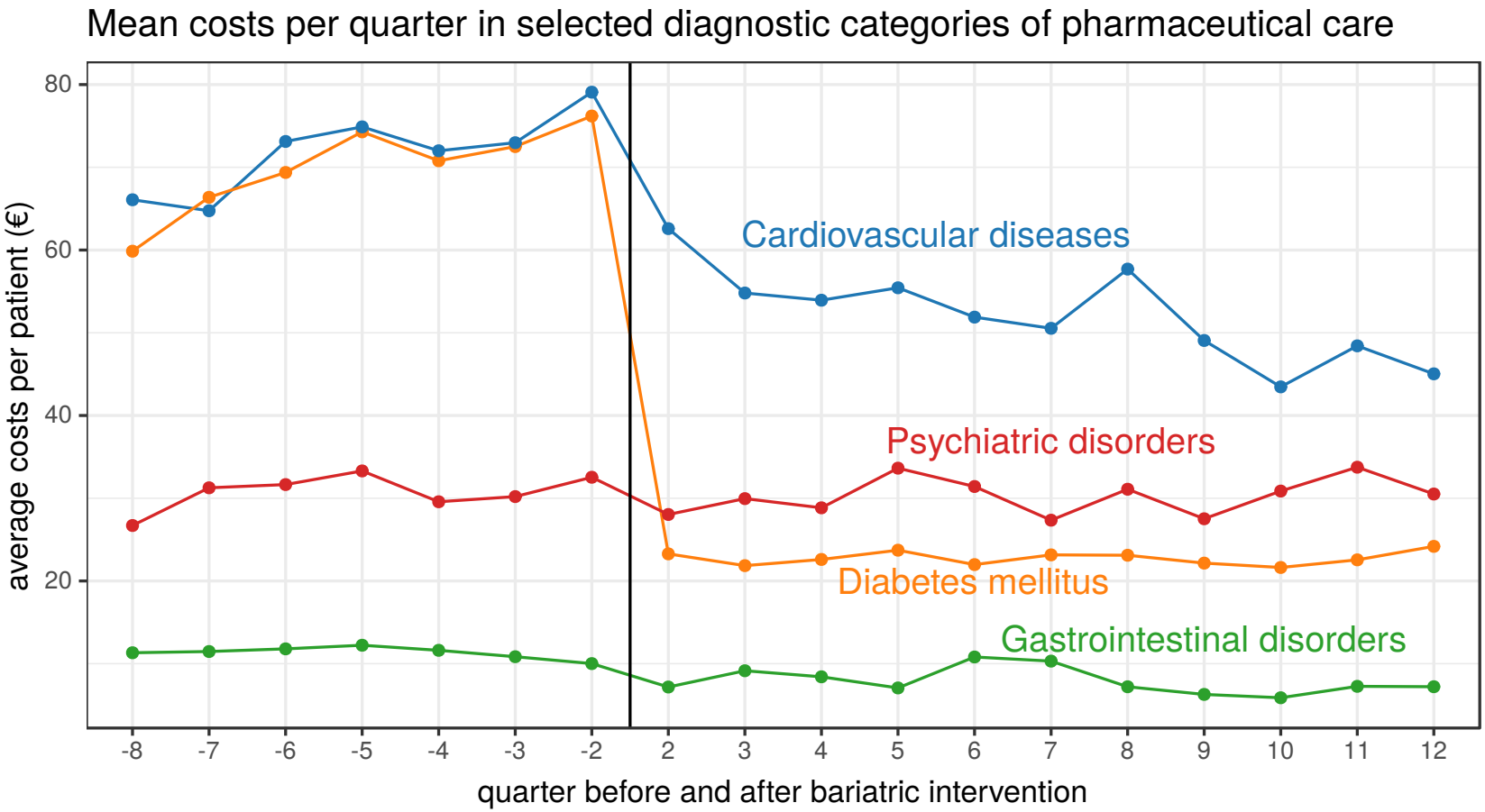
black line: actual costs

blue line: counterfactual costs (predicted costs without bariatric surgery)

Hospital costs increase after bariatric surgery

	Average expenditures after bariatric surgery		
	Medication	Physician	Hospital
Actual	265	240	677
Predicted	373	355	397
95% CI	[258, 450]	[148, 507]	[-59, 677]
Absolute effect	**-108**	**-115**	**278**
95% CI	[-183, 4]	[-266, 92]	[0, 736]
Relative effect	-29%	-32%	70%
95% CI	[-49%, 1%]	[-75%, 26%]	[0%, 185%]
Posterior tail area prob. p	0.03	0.07	0.02
Posterior prob. of causal effect	97%	93%	98%

Medication costs for diabetes and cardiovascular diseases are lower after surgery



Conclusion

- Increased hospital costs after bariatric surgery (possible due to complications and follow-up procedures)
- Lower medication and physician costs
- In total, slightly increased costs after bariatric surgery during our post-intervention period

Thank you

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