The Human Cost of Collusion: Health Effects of a Mexican Insulin Cartel

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Motivation

1. **How to regulate markets when faced with weak institutions?**
   - Corruption, lack of enforcement resources, or insufficient fines for infractions can undermine regulation.
   - Prevalent issue facing many developing countries.
2. **What are the downstream costs of collusion?**
   - Often use price changes to capture the effects of cartels.
   - Cartels can cause harm in many other ways, such as labor/capital market distortions or adverse health effects.
   - Empirical literature has struggled to directly measure these effects.

Pharmaceutical collusion in Mexico

This paper studies an insulin bidding ring in the procurement market of IMSS, a large public health care provider in Mexico.

Weak institutions: weak antitrust regulator struggled to prevent and punish collusion.

- Paltry antitrust fines, limited enforcement capabilities.
- Instead of traditional enforcement, IMSS changes market design.

Adverse health effects of collusion: access to insulin is necessary for long-term management of diabetes.

- Millions of individuals with diabetes obtaining health care through IMSS.
- Health surveys and vital records cause-of-death data allow tracking of diabetes-related health outcomes over time.

Results preview

Empirical findings:

- Market changes effectively ended cartel activities: price of insulin declined 78%, and quantity purchased increased 149%.
- Use diff-in-diff specification to measure health outcomes for IMSS diabetics relative to others in the public health system:
  - Insulin utilization increased by 42%.
  - Diabetes complications decreased by 25%, per-year diabetes-specific mortality decreased by 3.4%.

Policy takeaways:

- Market design can alleviate the weak institutions problem and help to implement regulation.
- Cartels have far-reaching consequences that can result in direct consumer harm in addition to price distortions.

Related literature

Pharmaceutical markets in developing countries: Chatterjee et al. (2015), Duggan et al. (2016), Bennett and Yin (2019)

Market power and health care quality: Beaulieu et al. (2020), Gaynor et al. (2013), Bloom et al. (2015)

Empirical studies of cartels: Levenstein and Suslow (2006, 2015), Asker and Nocke (2021)

- Jacquemin and Slade (1989) wrote that "too much time is being spent in estimating the area of triangles and not enough effort is being expended on assessing other consequences of monopoly."

Contents

Health care in Mexico

- Health care in Mexico is primarily delivered through the public sector, with a small fraction using private health care.
- The largest component of public health care is **Social Security**:
  - Set of programs that provide care for employed workers and families.
  - IMSS covers private sector workers and is the largest Social Security program, covering 43 million individuals in 2013.
  - Each social security program has a separate provider network.
- Other main public health care program is *Seguro Popular*, designed to provide health care to uninsured individuals.
  - Launched in 2003 and now covers over 50 million individuals.

Diabetes treatment in Mexico

- Diabetes is a major public health concern in Mexico: deaths from diabetes accounted for 14% of all deaths from 2010 - 2018.
- Severe outcomes associated with diabetes.
  - Excess mortality rates from diabetes are double that of developed countries (Alegre-Díaz et al. (2016)).
- Limited access to treatment.
  - Low funding for public health sector generated excess demand and implicit rationing (OECD (2005)).
  - Low rates of insulin use: 7 - 13% of diabetes patients in Mexico use insulin, compared with 30% in US (CDC).
  - Inability to access treatment cited as a key factor in high diabetes mortality rate (Herrington et al (2018)).

Obtaining insulin through IMSS

- Insulin prescription guidelines standardized across all public health agencies starting in 1994.
- Guidelines use biomarker targets, notably HbA1c.
- Insulin is nominally free for IMSS beneficiaries but evidence is highly suggestive of insulin shortages:
  - Numerous studies find low rates of insulin use but high prevalence of HbA1c outside recommended range.
  - Anecdotal reports of social security beneficiaries purchasing insulin on the private market are common.
  - Household expenditure data shows positive out-of-pocket expenditures on diabetes medications for social security beneficiaries.

IMSS insulin procurement

- Procurement auctions are held to acquire the medical supplies needed by IMSS.
- Prior to 2007 there were more than 70 insulin auctions per year across 52 separate procurement divisions.
- Same auction rules across all divisions:
  - First price sealed bid.
  - Identical reserve price.
  - Individual bids are revealed to all participants.
- From 2003 to 2005, a four-firm bidding ring controlled the IMSS insulin market.
- These firms used a bid rotation strategy to control auction bids:
  - Winning bids at (or just below) the reserve price of $155.
  - Other firms submitted bids between $157.50 and $158.50.

Insulin bidding ring collapse

- IMSS made two changes to the design of the market, suggested by CFC:

1. Jan 1st, 2006: Entry restrictions removed.
   - Removed requirement that firms operate a licensed insulin production factory within Mexico (no distributors or importers).
   - On Jan 30th, a new firm, Dimesa, entered the market.
2. 2007: Procurement consolidation.
   - Disjoint procurement divisions consolidated under centralized authority.
   - From 2006 to 2007, annual insulin auctions decreased from 76 to 9.

Theoretical framework

- Changes proposed by CFC were motivated by market design principles.
  - Entry long known to destabilize cartels (Levenstein and Suslow (2006)).
  - High frequency of interaction is also a cause for concern (Marshall and Marx (2012)).
- Consider the following homogeneous product market:
  - $I \geq 2$ firms with constant marginal costs c.
  - Single consumer with multi-unit demand: all units up to q are valued at $v > c$, any additional have zero value.
  - Bertrand competition, with lowest-price firm i selling q units to the consumer provided $p_i \leq v$.
  - Per-period profits are $\pi_i(p_i) = q(p_i - c)$ for the winning firm. Profit is split among winners if tied.

Theoretical framework

- Market repeats, firms discount future profits at rate $\delta \in (0, 1)$.
- Static Nash equilibrium: all firms submit prices $p_i = c$ and earn zero profits.
- Optimal collusion with grim trigger strategies where all firms submit $p_i = v$ and split profits.
- Letting π^C denote per-period collusive profits, collusion is sustainable if

$$\sum_{t=0}^{\infty} \delta^t \pi^C = \frac{\pi^C}{1-\delta} \geq q(v-c) \quad \Rightarrow \quad \frac{q(v-c)}{I(1-\delta)} \geq q(v-c)$$

1. Increase in number of firms to $\tilde{I}$ such that $\tilde{I} > \frac{1}{1-\delta}$ will destabilize cartel.
2. Reduction in auction frequency such that $\tilde{\delta} < 1 - \frac{1}{I}$ will destabilize cartel.

Facilitating cartel renegotiation

- Consolidation also interferes with the cartel through encouraging renegotiation.
- When renegotiation is costless, collusion is extremely difficult to maintain. If renegotiation is costly, collusion can be restored.
- McCutcheon (1997) proposes that small antitrust fines can *encourage* collusion by preventing renegotiation:
  - Fine is the risk of being caught discussing explicit collusion.
  - If the expected fine is larger than total discounted collusive profits, collusion won't occur.
  - But fines large relative to profit from a *single period* will prevent cheating and renegotiation.
- Consolidation increases per-period profits and makes fines relatively smaller $\rightarrow$ renegotiation more attractive.

Facilitating cartel renegotiation

- Minimum punishment time to discourage collusion is the smallest T such that $1 - \frac{1}{I} \leq \delta(1 - \frac{\delta^T}{I})$.
- The total cost of punishment for a cheating cartel member is the lost profit for T periods:

$$\gamma(\pi^C, \delta) = \pi^C \left(\frac{1 - \delta^T}{1 - \delta} \right).$$

- If the renegotiation cost is less than γ, cheating will be optimal.
- Consolidation combines N sales together and has two effects:
  - Greater time between sales: discount factor becomes δ^N.
  - Increased profit per-sale: profit is $N \times \pi^C$.
- Consolidation always increases punishment costs, making cheating worthwhile for firms and undermining collusion.

Participation in IMSS insulin auctions

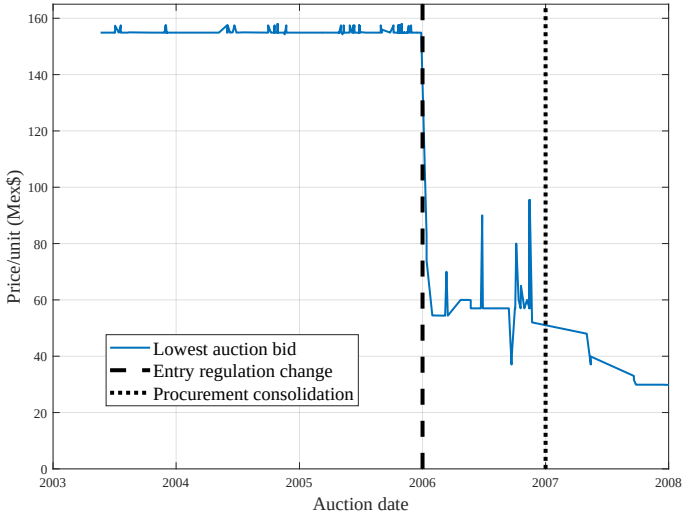
Participation by firm in IMSS insulin auctions, May 2003 through Dec 2007.

Firm	Auctions Won	Auctions Participated
Cryopharma*	102	259
Pisa*	111	215
Eli Lilly*	75	189
Probiomed*	91	122
Dimesa+	43	57
Savi	10	18
SMS	10	16
Maypo	7	15
Audipharma	3	6
Codifarma	1	9

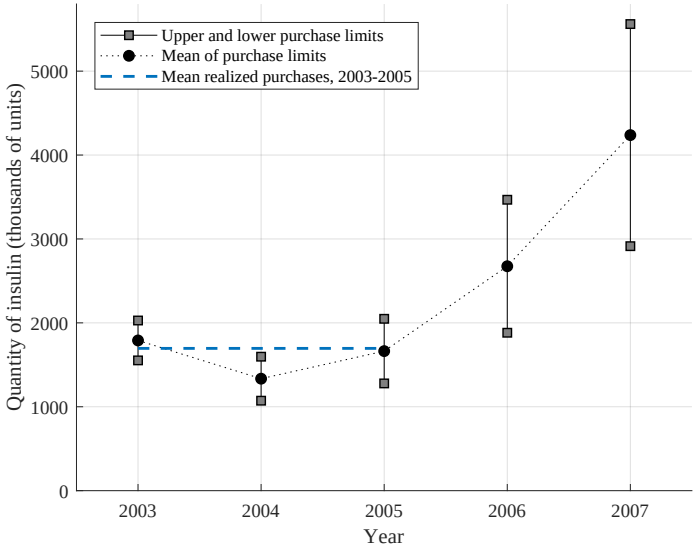
Note: * indicates cartel member, + indicates 2006 entrant.

The four cartel participants and 2006 entrant Dimesa accounted for 93% of auction wins.

Market changes facilitate cartel collapse



IMSS increases insulin quantity



Legal proceedings

- In 2010, six firms and several individuals were found guilty of bid manipulation.
- Bid-rigging occurred for two types of drugs: insulin and saline solutions.
- Each firm was issued maximum allowable fine: $1.7 million US dollars.
- Legal case showcases the weak institutions problem.
  - Extremely small fines: about 10% of the revenue each firm obtained in the insulin market alone.
  - No direct evidence of conspiracy: CFC forced to rely on indirect evidence of conspiracy (no search warrants or wiretaps).

Estimating the health effects of the cartel's collapse

- The increased insulin purchases by IMSS demonstrates a substantial increase in insulin availability
- Suggests that health outcomes of IMSS diabetes patients may have improved following the cartel's collapse.
- I use three data sets on health outcomes in Mexico covering 2000-2016 to assess the impact of the cartel's collapse on diabetes outcomes.
- Each specification compares IMSS diabetes patients with diabetes patients enrolled in similar health insurance.
  - Three outcomes: insulin utilization, diabetes complications, and diabetes-specific mortality risk.

Econometric specification

- Main specifications utilize difference-in-differences (DiD) framework.

$$Y = X\beta + \delta_0 \text{Insurance} + \delta_1 \text{Year} + \delta_2 \text{IMSS} \times \text{Post-Cartel} + \epsilon$$

- X is a set of demographic and health controls.
- Treatment group is diabetic patients within IMSS, control group is diabetic patients covered by another social security program.
- DiD coefficient is δ_2, which captures changes in outcome variable among IMSS diabetic patients relative to the control group.
- Standard errors clustered by insurance provider.
  - p-values calculated using wild cluster bootstrap (Cameron et al (2008)) for linear specifications and score bootstrap (Kline and Santos (2012)) for nonlinear specifications.

Identification

- This framework treats the collapse of the insulin cartel as a shock to insulin availability affecting IMSS diabetic patients.
- The control group is composed of diabetic patients from other social security programs.
- Specifically, I do not include individuals insured with private health insurance or through *Seguro Popular* in the control group.
- Identifying assumption: in the absence of the cartel's collapse, diabetes treatment would have evolved similarly across all social security programs.

Data on insulin utilization and diabetes complications

- Encuesta Nacional de Salud y Nutrición (ENSANUT) survey.
  - Household survey (repeated cross-section) recording demographic, social, economic, and health information.
  - Interviews conducted in 2005, 2011, and 2015.
  - Measures insulin utilization and complications from diabetes.
- Complications are ulcers, loss of sensation, amputation, vision deterioration, retinal damage, blindness, dialysis, and heart attack.
- All of these are associated with poor long-term management of diabetes.

ENSANUT summary statistics

	ENSANUT 2006	ENSANUT 2012	ENSANUT 2016
Total survey size	45,241	46,277	8,824
Number of individuals with diagnosed diabetes	3,066	4,490	972
Health:			
Complications	0.98	1.18	1.24
	(1.15)	(1.23)	(1.23)
Insulin	0.07	0.12	0.19
	(0.26)	(0.32)	(0.39)
Diabetes duration (years)	8.37	8.88	10.79
	(7.74)	(9.07)	(8.62)
Smoking	0.27	0.33	0.27
	(0.44)	(0.47)	(0.44)
Hypertension	0.41	0.47	0.48
	(0.49)	(0.50)	(0.50)
High cholesterol	0.21	0.23	0.24
	(0.41)	(0.42)	(0.43)
Alcohol	0.40	0.21	0.11
	(0.49)	(0.40)	(0.31)
Demographics:			
Age	56.77	57.59	58.87
	(13.61)	(13.24)	(12.54)
Height (m)	1.56	1.56	1.54
	(0.09)	(0.10)	(0.09)
Weight (kg)	71.10	72.28	71.06
	(15.11)	(15.71)	(15.32)
Waist measurement (m)	1.00	0.99	1.00
	(0.13)	(0.13)	(0.13)
Sex (male)	0.39	0.38	0.32
	(0.49)	(0.49)	(0.47)

Effect on insulin utilization and diabetes complications

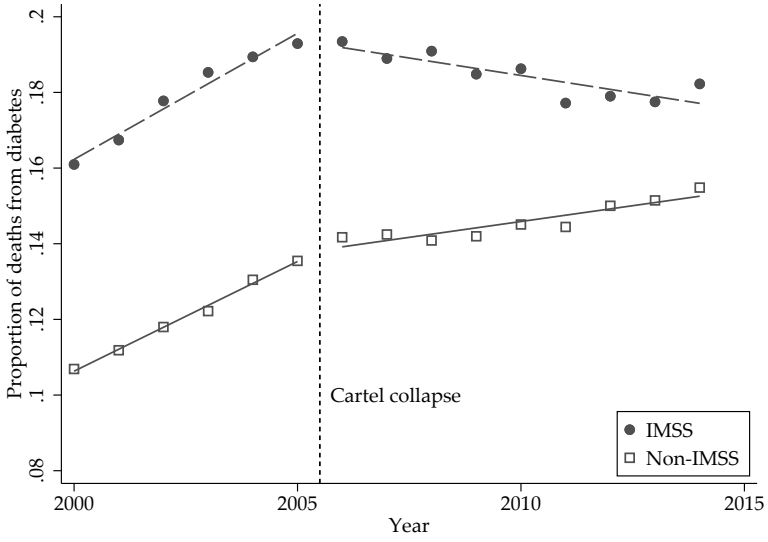
	Insulin		Complications	
	(1)	(2)	(3)	(4)
DiD coeff.	0.050	0.050	-0.302	-0.299
p-value	(0.035)	(0.035)	(0.034)	(0.027)
95% CI	$[0.02, 0.22]$	$[0.02, 0.21]$	$[-0.57, -0.10]$	$[-0.53, -0.15]$
Base controls	X	X	X	X
Health controls		X		X
Observations	5,773	5,773	5,773	5,773

- Insulin usage increase of 42%.
- Complications from diabetes decreased by 25%.

Mortality data

- To measure the effect on mortality, I use Instituto Nacional de Estadística y Geografía (INEGI) vital records data
- Includes information on all recorded deaths from 2000 to 2014:
  - Age at death.
  - Cause-of-death.
  - Insurance coverage.
  - Primary residence location.
  - Education and occupation information.
- Final sample has over four million observations.

Diabetes deaths decline following cartel collapse



Effect on diabetes mortality

- To measure mortality effects, I estimate a proportional hazards model of diabetes-specific mortality:

$$\lambda(t|X_i) = \lambda_0(t)\exp(X\beta),$$

$$X\beta = \beta_1 \text{State} + \beta_2 \text{Insurance} + \beta_3 \text{Year} + \beta_4 \text{IMSS}_i \times \text{Post-Cartel}$$

- The hazard function $\lambda(t|X_i)$ represents the probability of dying from diabetes before age $t+1$ conditional on living to age t.
- Captures dynamic effects better than relative risk: individuals may still die from diabetes-related complications, but may do so at later ages than in the counterfactual.

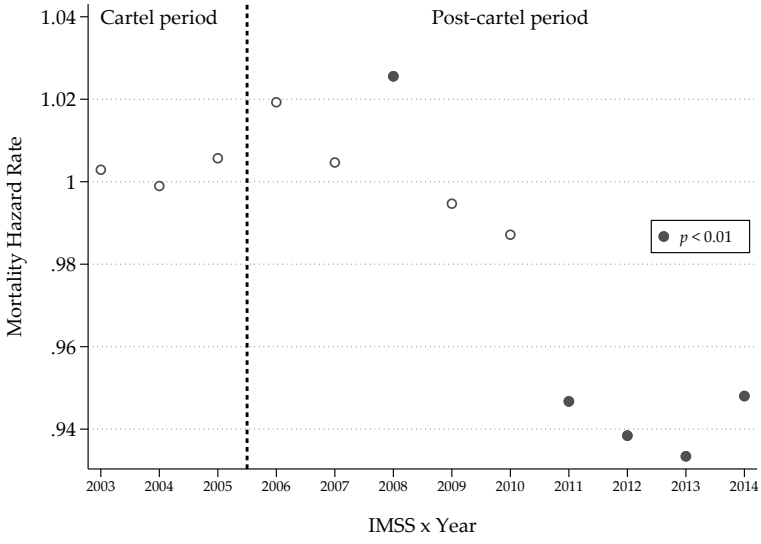
Effect on diabetes mortality

Table: Diabetes-specific mortality hazard rates

	(1)	(2)
DiD hazard ratio	0.966	0.954
p-value	(0.000)	(0.000)
Education		X
Occupation		X
Observations	4,051,016	3,059,789

- Per-year reduction in diabetes mortality of 3.4%.
- This corresponds to 971 premature diabetes deaths per year of the cartel's operation.

Effect on diabetes mortality by year



Results discussion

- Overall, effects are large relative to existing literature on increased pharmaceutical availability.
- For mortality, closest study is Américo and Rocha (2020) who study insulin subsidies in Brazil and find weak effects on mortality.
- Most other studies focus on Medicare Part D.
  - Increased medication utilization by $\approx$ 6 - 13%, compared to 42% for IMSS insulin.
  - Mixed effects on non-mortality outcomes, e.g. cholesterol levels (Hanlon et al. (2013)), compared to 25% reduction in diabetes complications.
  - Similar mortality effects overall (Dunn and Shapiro (2019)).

Robustness

- Placebo tests:
  - Pre-trends in insulin utilization using 2000 ENSA survey.
  - Non-pharmaceutical treatment adherence (nutrition plan).
- Robustness to functional form.
- Selection tests using longitudinal MXFLS data:
  - Selection into IMSS insurance post-cartel.
  - Change in diabetes diagnosing behavior within IMSS post-cartel.
- Spillovers from IMSS procurement changes onto other public health procurement.

Insulin utilization pre-trends and other placebo tests

Panel A: Insulin usage 2000 vs 2006		
	(1)	(2)
IMSS × 2006	0.009	0.009
p-value	(0.709)	(0.739)
95% CI	$[-0.16, 0.03]$	$[-0.14, 0.04]$
Base controls	X	X
Health controls		X
Observations	4,145	4,145
Panel B: Other treatment		
	(3)	(4)
DiD coeff.	-0.004	-0.004
p-value	(0.898)	(0.901)
95% CI	$[-0.04, 0.21]$	$[-0.04, 0.19]$
Base controls	X	X
Health controls		X
Observations	5,773	5,773

Robustness to functional form

	Insulin		Complications	
	(1) Probit	(2) Logit	(3) Poisson	(4) Log
DiD coeff.	0.296	0.473	-0.314	-0.152
p-value	(0.032)	(0.040)	(0.047)	(0.023)
Base controls	X	X	X	X
Health controls	X	X	X	X
Observations	5,307	5,307	5,773	5,773

- Results robust to various functional form assumptions.
- Also examines robustness of different formulations for the parallel trends assumption.

Selection and diabetes diagnoses

	(1) DV: Switch to IMSS Sample: non-IMSS beneficiaries	(2) DV: Diabetes diagnosis Sample: non-diabetics
Diabetes × Post	0.023	
IMSS × Post		0.010
p-value	(0.492)	(0.260)
95% CI	$[-0.04, 0.09]$	$[-0.18, 0.13]$
Base controls	X	X
Health controls	X	X
Observations	11,349	10,148

- Column (1) tests whether individuals with diabetes were more likely to switch into IMSS coverage after the cartel's collapse.
- Column (2) tests whether diabetes diagnoses became more prevalent within IMSS after the cartel's collapse.

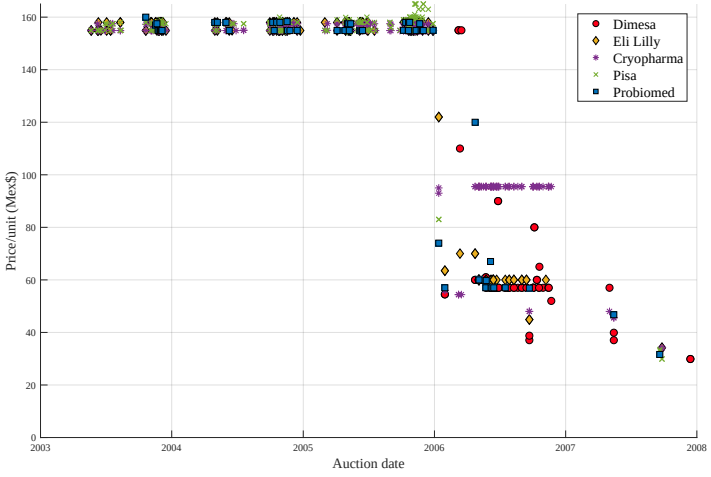
Spillovers

- Finally, I look for spillovers from IMSS procurement changes that (negatively) affected other public insulin procurement.
- Potentially caused by capacity constraints, increasing marginal costs, or changes in firm conduct.
  - Winning bid is constant from 2009 - 2015 as quantity doubles $\rightarrow$ constant marginal cost.
  - Large increases in production and relaxation of import rules $\rightarrow$ no capacity constraints.
  - No changes in private sector prices or non-IMSS out-of-pocket diabetes expenditures $\rightarrow$ limited changes in firm conduct.
- Indirect test: using privately insured individuals as the control group yields similar results.

Conclusion

- Main findings:
  - Market power wielded by an insulin cartel restricted the supply of insulin to a large public health care provider.
  - Straightforward market design changes successfully eliminated the cartel's ability to collude.
  - Health outcomes for diabetes patients improved following the cartel's collapse.
- Main takeaways:
  - Market design can help achieve regulatory goals when institutions are weak.
  - Consequences of collusion are far-reaching, and cartels have the potential to impact the health and well-being of individual consumers.

All bids


Dimesa
Eli Lilly
Cryopharma
Pisa
Probiomed
Price/unit (Mex$)
Auction date
0
20
40
60
80
100
120
140
160
2003
2004
2005
2006
2007
2008

ENSANUT balance table

	(1) Pre×Control	(2) Pre×IMSS	(1) - (2)	(3) Post×Control	(4) Post×IMSS	(3) - (4)
Health:						
Complications	0.84	1.03	-0.19	1.09	1.19	-0.10
	(1.08)	(1.13)		(1.18)	(1.20)	
Insulin	0.10	0.10	0.00	0.08	0.18	-0.10
	(0.30)	(0.29)		(0.28)	(0.39)	
Diabetes duration (years)	8.88	9.32	-0.44	8.19	10.10	-1.91
	(8.18)	(8.12)		(8.46)	(9.35)	
Demographics:						
Age	57.41	58.39	-0.98	56.30	59.82	-3.53
	(12.81)	(12.69)		(13.13)	(12.26)	
Sex (male)	0.39	0.36	0.02	0.43	0.32	0.11
	(0.49)	(0.48)		(0.49)	(0.47)	
Height (m)	1.57	1.56	0.01	1.57	1.56	0.01
	(0.10)	(0.09)		(0.10)	(0.09)	
Weight (kg)	73.63	72.18	1.45	73.62	72.67	0.95
	(15.93)	(14.74)		(16.26)	(15.12)	
Waist measurement (m)	1.01	1.01	0.00	1.00	1.00	-0.01
	(0.12)	(0.13)		(0.13)	(0.13)	

Comparison to saline solutions