# The Life Saving Effects of Hospital Proximity

**Paola Bertoli**

University of Economics in Prague

CERGE-EI

**Veronica Grembi**

Copenhagen Business School

AES Granada – June 18th, 2015

# Motivation

Response time and access to Emergency Department is crucial for some pathologies:

- Pell et al. (BMJ, 2001): Heart diseases
  - reducing by 5 minutes higher response times increases survival probability by 10/11%
- American Heart Association
  - Death rate for patients in ED by 30 minutes= 3.6%
  - Death rate for patients in ED by 30-45 minutes= 7%
  - Death rate for patients in ED later than 45 minutes= 10.8%
  - The first 90 minutes are crucial to survive
  - *Golden hour*=60 minutes after the first symptoms of a stroke

# Motivation

The cost-benefit effects of hospital proximity are hard to estimate:

1. access to care, which affects
   - mortality (Buchmueller et al. 2006; Yamashita and Kunkel 2010; Advic 2014)
   - travel time (Capps et al. 2010)
   - checkups (Currie and Reagan 2003)
2. resource savings & efficiency of the sector (Lindrooth et al. 2003; Holmes et al. 2006; Bloom et al. 2011)
3. quality of healthcare services

Identification problem: SPATIAL SORTING

# Related Literature: The Closure Approach

| Study | Outcome | Treatment | How | Effect |
|---|---|---|---|---|
| Buchmueller et al. (2006, JHE) | AMI survival<br>Injuries<br>No Emergency | Euclidean distance<br>Centroid zip code<br>to H<br>address | Exploiting<br>Hospital<br>Closures<br>DD | +1.6km=+6.5% AMI mortality<br>→1 extra death per zip code/year<br>→+11/20% injury mortality<br>→+0.5 death per zip code/year |
| Advic (2014) | AMI survival | Euclidean distance<br>SAMS to H | OLS<br>several<br>specifications | +10km=-3% AMI survival<br>Moving from +10 to +50<br>-15% AMI survival probability |

- Pros: it does not take distance as exogenous
- Cons:
  - It takes closure as random
  - It sets a specific date to a closure
  - It identifies through a small fraction of changes (i.e., 0.005%)

# Our Contribution

1. We exploit a natural experiment in Italy, where since 1968 hospital location is constrained by population size (>25,000)
   - IV $\Rightarrow$ we instrument hospital proximity with distance to nearest municipality above 25,000 in 1971

2. We focus on road-traffic accidents (as opposed heart attacks): 2000-2012

Focus on accidents:

- Results relevant for emergency care in general
- Policy implications need caution: we just look at a potential cost

# Data

1. *Distance*: Hospital proximity= Euclidean distance (from centroid to centroid distance) of each municipality (7,954) to the nearest hospital
2. *Fatality*: Data on road-traffic accidents at the municipal level
   Accidents registered on occurrence (no info on deaths on impact)
   - Number of accidents
   - Number of deaths
3. Emergency network data (2005): *Radio coverage*, *Physicians*, *Helicopter use*, *Medical cars*
4. Hospital data (2010): National Plan Outcomes (*Piano Nazionale degli Esiti*) monitoring program run by the Ministry of Health. $\Rightarrow$

   Volumes data (AMI, Stroke, CHF, and Non Oncological Surgeries)

# Estimation (1)

Empirical model:

$$Fatality_{mt} = \delta Distance_m + Z_m^{'}\sigma + X_{mt}^{'}\tau + \gamma_h + \pi_p + \beta_t + \epsilon_{mt} \quad (1)$$

- $Fatality$=No. of deaths/No. of accidents
- $Z_m^{'}$=altitude categories, coastal dummy
- $X_{mt}^{'}$=income, population density
- $\gamma_h$= hospitals fixed effect
- $\pi_p$= provincial fixed effect
- $\beta_t$= year fixed effect

# Estimation (2)

1. We estimate a basic OLS
2. We exploit the info on 25 closures (rehabilitation centers) to estimate a DD (i.e. $Distance_{mt}$)
3. We instrument $Distance_m$ with $Distance\ 1971_m$ (IV)
4. We also augment these IV specifications with flexible control functions of population in 1971 $f(Pop1971\_25000)$ in the spirit of a RD

# IV Identification

1968 Law set at 25,000 inhabitants the minimum requirement for the construction of a new hospital

- Next Census in 1971 shifts
- NHS: 1978

We instrument *Distance* with:

- Distance of each municipality to the nearest city that in the 1971 Census was (just) above 25,000 dbn

The reduced-form and the first stage equations are:

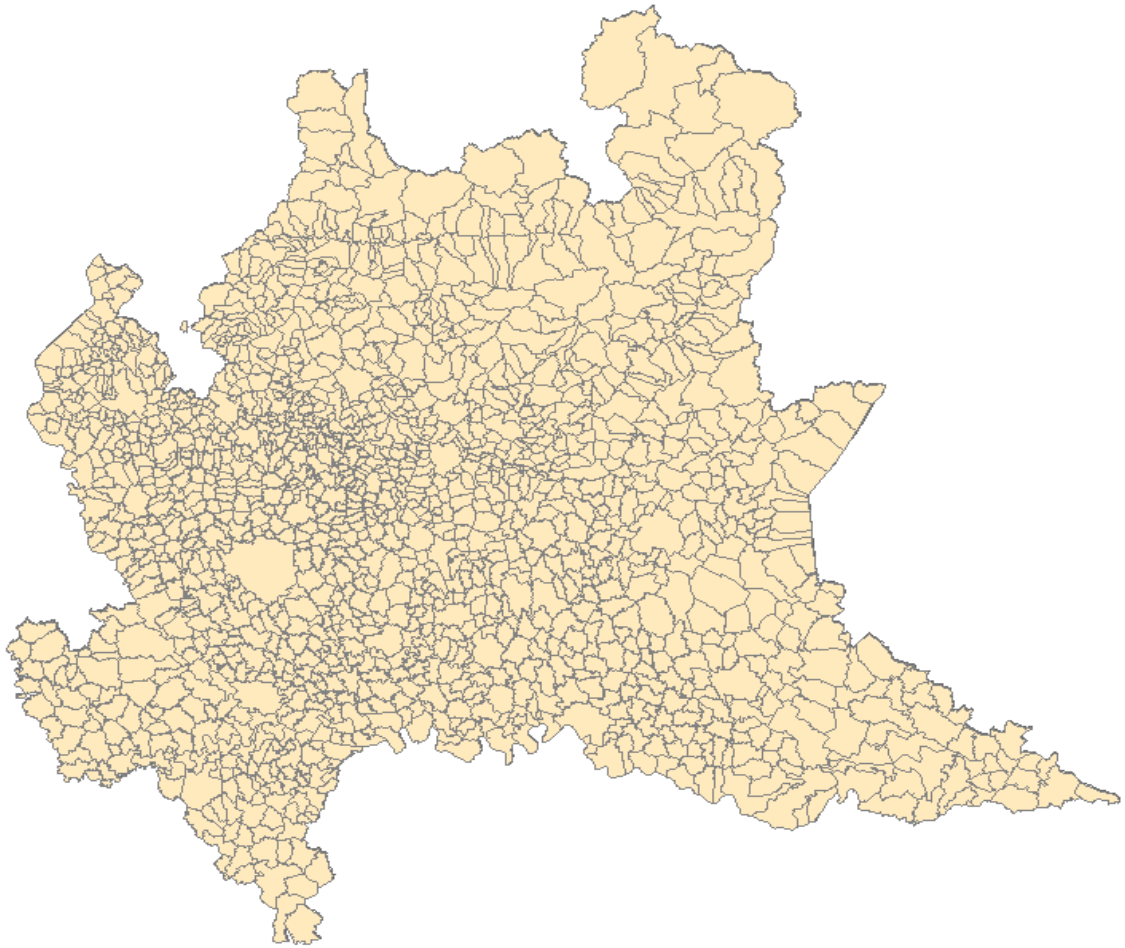
$$Fatality_{mt} = \alpha Distance\ 71_m + Z_m^{'}\sigma + X_{mt}^{'}\tau + \gamma_h + \pi_p + \beta_t + \epsilon_{mt}$$

$$Distance_m = \lambda Distance\ 71_m + Z_m^{'}\sigma + X_{mt}^{'}\tau + \gamma_h + \pi_p + \beta_t + \upsilon_{mt}$$

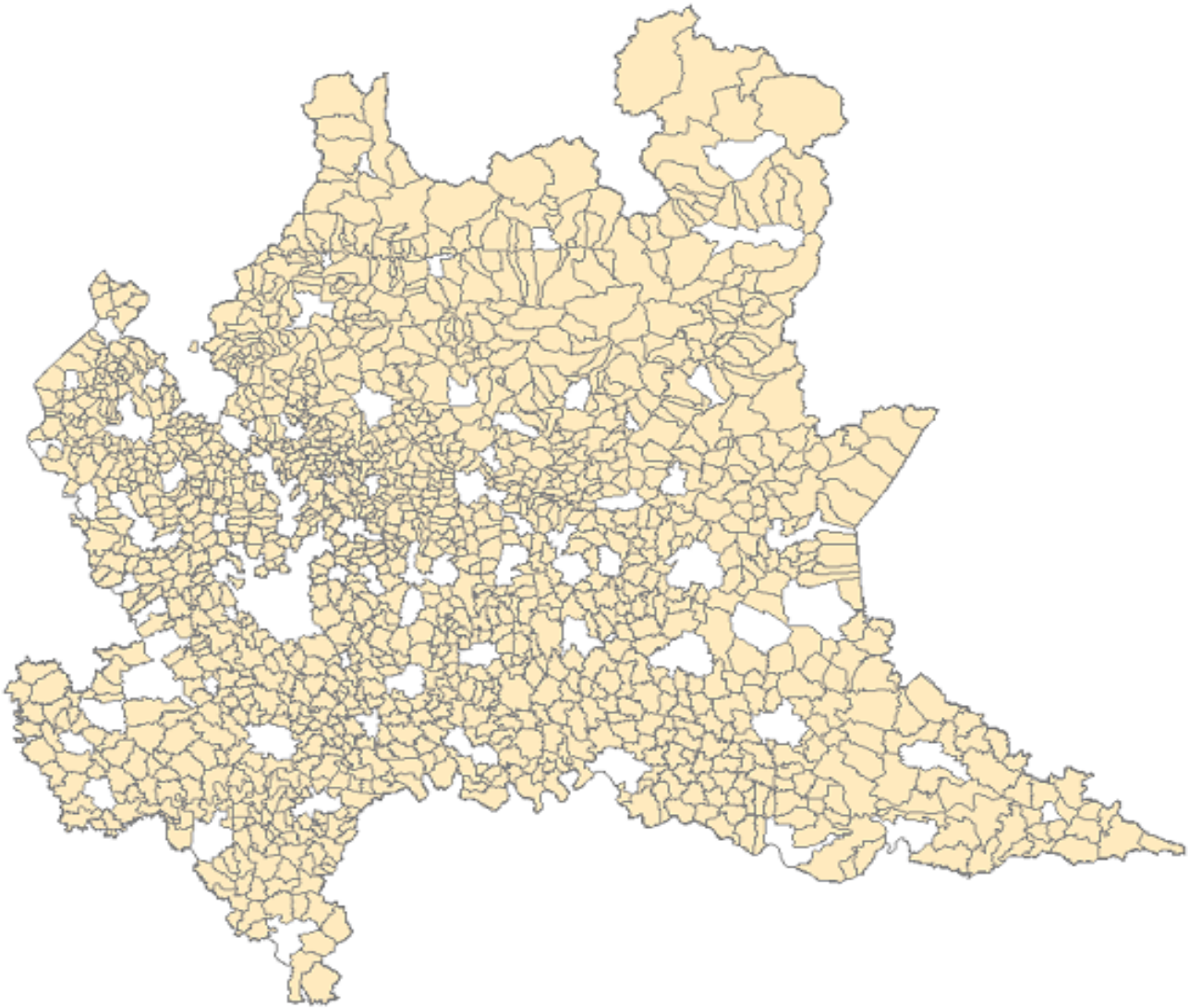
# Identification Assumptions

1. Instrument highly correlated to the instrumented variable⇒ first stage statistics
2. *Distance* 71⇒*Distance*⇒*Fatality*
   - Our strategy exploits randomness in municipality geographical distribution
   - We use 5 samples

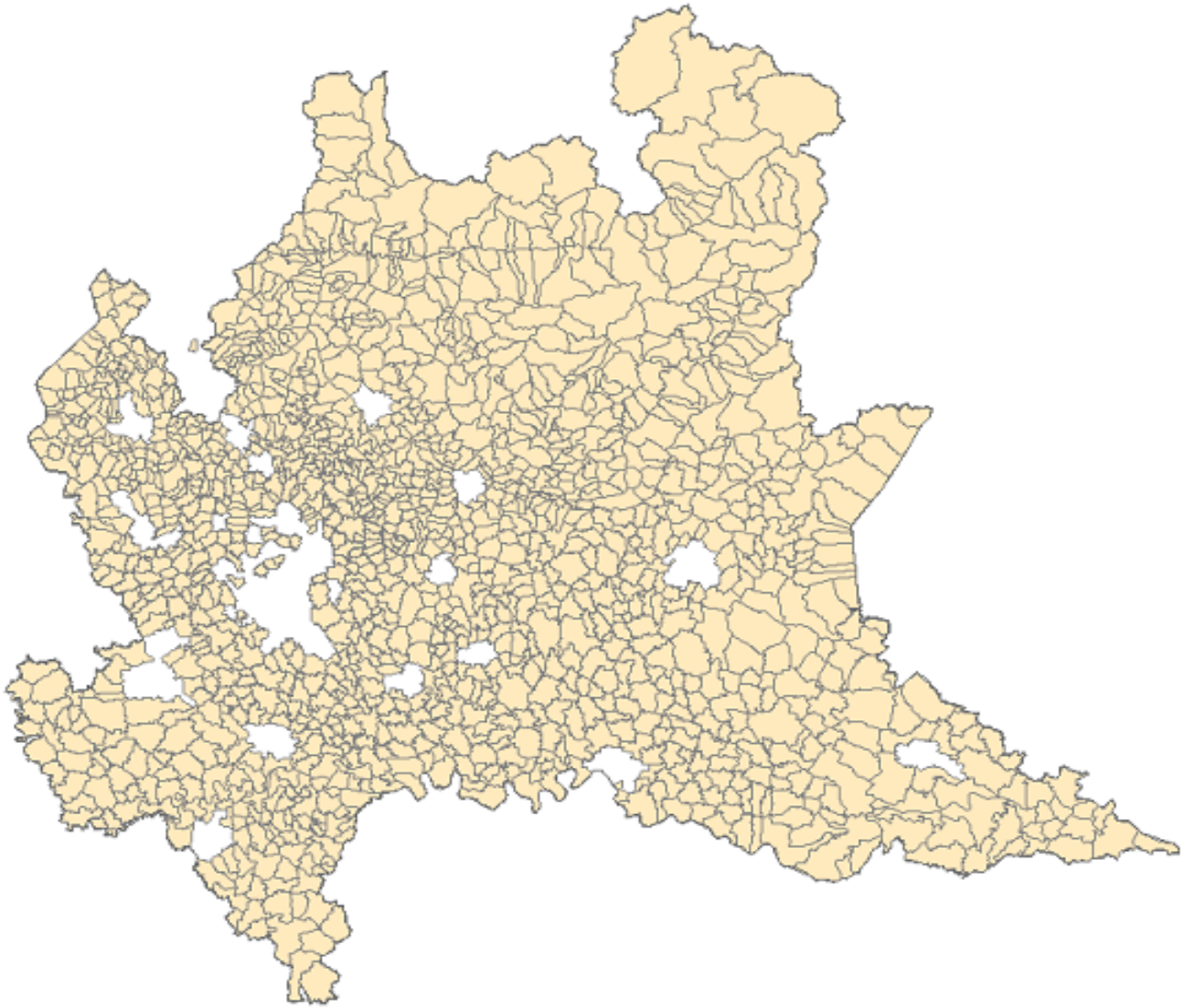
# Sample 1: All



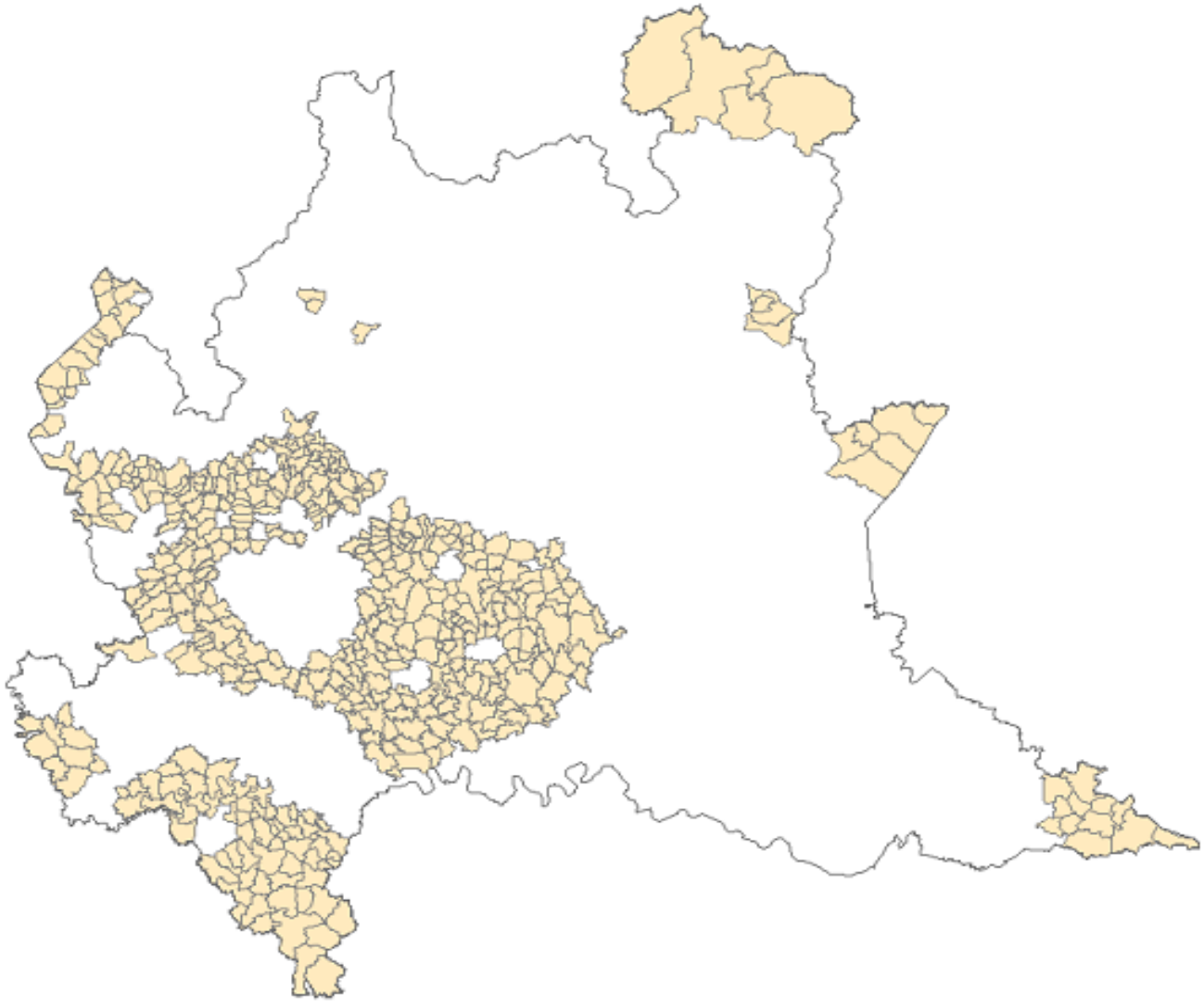
# Sample 2: No Hosp.+Pop1971<50,000



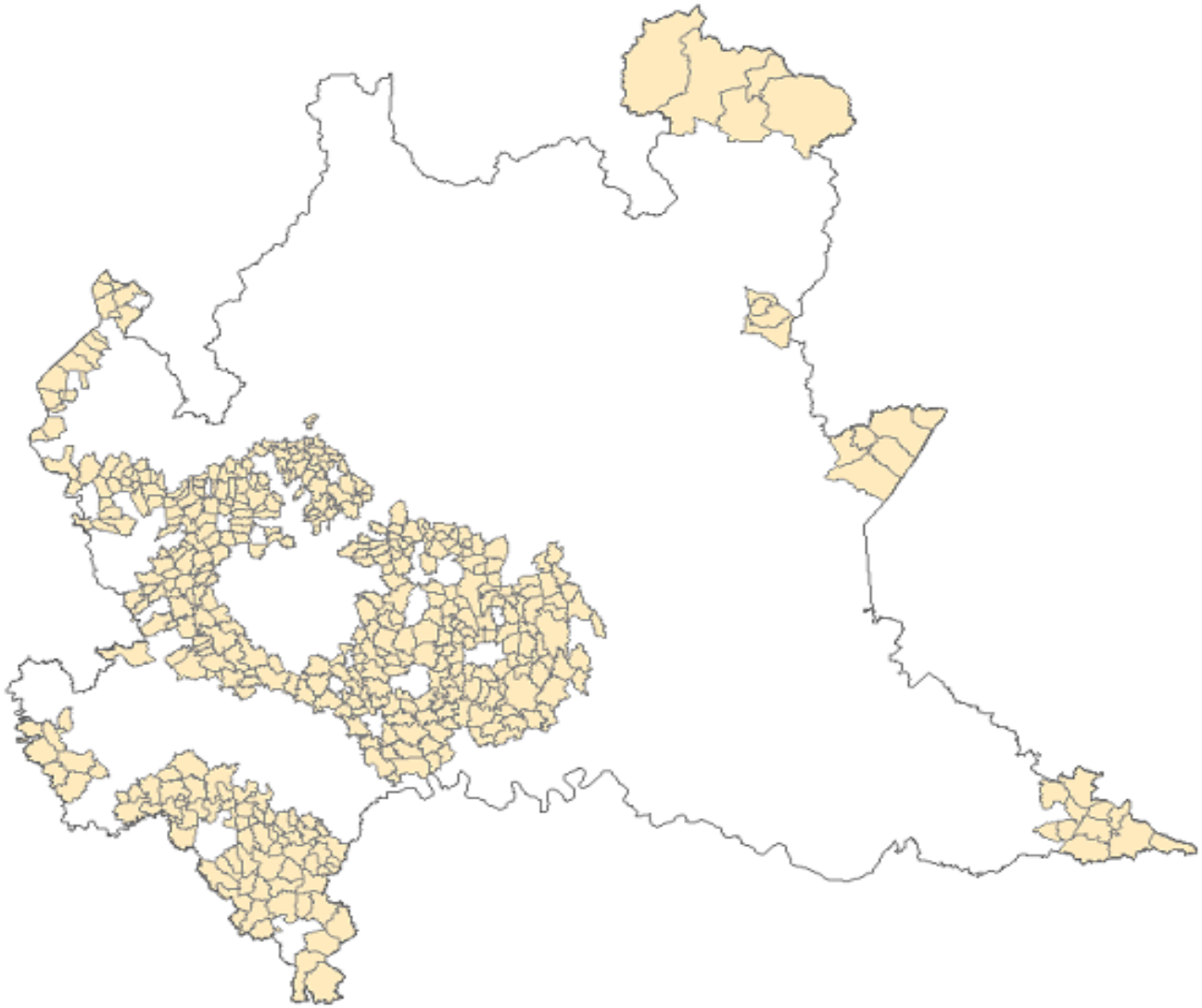
# Sample 3: Pop1971<25,000



# Sample 4: Pop1971<25,000+ Nearest <50,000



# Sample 5:Pop1971<25,000+Nearest<50,000+No Hosp.



# OLS Results: Fatality

| Variable | All | No Hosp + Pop1971<50,000 | Pop1971<25,000 | Pop1971<25,000 + Nearest<50,000 | Pop1971<25,000 + Nearest<50,000 + No Hosp |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| **Panel A: OLS** | | | | | |
| Distance | 0.078*** | 0.071*** | 0.081*** | 0.076*** | 0.057** |
| | (0.012) | (0.016) | (0.013) | (0.019) | (0.025) |
| Provincial FE | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes |
| Nearest H. FE | Yes | Yes | Yes | Yes | Yes |
| **Panel B: Difference in Differences** | | | | | |
| Distance | 0.079*** | 0.073*** | 0.082*** | 0.077*** | 0.059** |
| | (0.014) | (0.019) | (0.015) | (0.020) | (0.027) |
| Provincial FE | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes |
| Nearest H. FE | Yes | Yes | Yes | Yes | Yes |
| Treated | 318 | 314 | 316 | 136 | 134 |
| Observations | 81,212 | 71,900 | 77,473 | 42,296 | 38,790 |
| Municipalities | 7,954 | 7,219 | 7,665 | 4,266 | 3,985 |
| Mean | 6.046 | 6.357 | 6.236 | 6.519 | 6.687 |

# Distance to Nearest just above 25,000 as Instrument

| | All | | No Hosp + Pop1971<50,000 | | Pop1971<25,000 | |
|---|---|---|---|---|---|---|
| | IV 1 | IV 2 | IV 1 | IV 2 | IV 1 | IV 2 |
| **Second Stage Statistics: Fatality** | | | | | | |
| Distance | 0.133*** | 0.129*** | 0.161*** | 0.158*** | 0.171*** | 0.168*** |
| | (0.034) | (0.034) | (0.045) | (0.045) | (0.0489) | (0.049) |
| Provincial FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Nearest Hospital FE | Yes | Yes | Yes | Yes | Yes | Yes |
| 3rd order Polynomial | No | Yes | No | Yes | No | Yes |
| **First Stage Statistics: Distance to the Nearest Hospital** | | | | | | |
| Distance_1971 | 0.324*** | 0.323*** | 0.281*** | 0.280*** | 0.253*** | 0.252*** |
| | (0.016) | (0.016) | (0.015) | (0.015) | (0.016) | (0.016) |
| $R^2$ | 0.509 | 0.51 | 0.567 | 0.567 | 0.491 | 0.492 |
| *Robust F* | 426.553 | 422.419 | 349.678 | 347.761 | 235.301 | 233.197 |
| Observations | 81,212 | 81,212 | 71,900 | 71,900 | 77,473 | 77,473 |
| Municipalities | 7,954 | 7,954 | 7,219 | 7,219 | 7,665 | 7,665 |
| Mean | 6.046 | 6.046 | 6.357 | 6.357 | 6.236 | 6.236 |

# Distance to Nearest above 25,000 as Instrument (2)

| | Pop1971<25,000 + Nearest <50,000 | | Pop1971<25,000 + Nearest <50,000 + No Hosp | |
|---|---|---|---|---|
| | IV 1 | IV 2 | IV 1 | IV 2 |
| **Second Stage Statistics: Fatality** | | | | |
| Distance | 0.200*** | 0.203*** | 0.185*** | 0.187*** |
| | (0.063) | (0.062) | (0.060) | (0.060) |
| Provincial FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| Nearest Hospital FE | Yes | Yes | Yes | Yes |
| 3rd order Polynomial | No | Yes | No | Yes |
| **First Stage Statistics: Distance to the Nearest Hospital** | | | | |
| Distance_1971 | 0.283*** | 0.284*** | 0.305*** | 0.306*** |
| | (0.022) | (0.022) | (0.020) | (0.020) |
| *Robust F* | 163.768 | 167.114 | 226.064 | 228.852 |
| Observations | 42,296 | 42,296 | 38,790 | 38,790 |
| Municipalities | 4,266 | 4,266 | 3,985 | 3,985 |
| Mean | 6.519 | 6.519 | 6.687 | 6.687 |

# Coefficients Interpretation (1)

- +1 km
  - $\Rightarrow$ +0.18 percentage points
  - $\Rightarrow$ +2.77% fatality rate
- +5 km (=1sd *Distance* in Sample 5)
  - $\Rightarrow$ +0.92 percentage points
  - $\Rightarrow$ +13.8% fatality rate
- +10 km
  - $\Rightarrow$ +1.8 percentage points
  - $\Rightarrow$ +27.68% fatality rate

# Coefficients Interpretation (2)

1. Translate every extra km in travel time
   - 50kmh, 70kmh, and 90kmh (Petzall et al. 2010, 85.8kmh)
2. How many extra death every 100 accidents?
3. Value of a Statistical Life (VSL)
   - A reference point for assessing the benefits of risk reduction efforts (Viscusi and Aldy, 2003)
   - Average EU 27 VSL (OECD, 2012): 4,131,970 euro

Using a dataset for 2 regions we investigate the OLS downward bias showing that the most severe accidents tend to happen near to the hospital

# When Proximity Matters: Mechanisms

3 mechanisms

1. Road Safety: More Severe Accidents
   - North-South: Less Safe Infrastructures+Low Enforcement of Road Safety Measures
2. ES Characteristics: Better and More Effectively Organized
   - Radio Coverage
   - Helicopter Use
   - Physicians
   - Medical Cars
3. Nearest Hospital Characteristics: High vs. Low Quality
   - Volumes (z-scored)
   - Hospital Fixed Effects

# Mechanisms (1)

| | | Emergency Service Characteristics | | | |
|---|---|---|---|---|---|
| | Road Safety | Radio Coverage | Helicopter Use | Physicians | Medical Cars |
| | **North** | **Less** | **Less** | **Less** | **Less** |
| *Distance* | 0.254 | 0.607*** | 0.552*** | 0.331* | 0.673*** |
| | (0.164) | (0.213) | (0.201) | (0.194) | (0.224) |
| | **South** | **More** | **More** | **More** | **More** |
| *Distance* | 0.719*** | 0.263** | 0.255* | 0.488** | 0.387** |
| | (0.241) | (0.178) | (0.186) | (0.192) | (0.193) |
| Difference | 0.465** | -0.344** | -0.297** | 0.157 | -0.360*** |
| | (0.210) | (0.136) | (0.136) | (0.128) | (0.130) |
| Observations | 38,790 | 35,681 | 35,681 | 35,681 | 35,066 |
| Municipalities | 3,985 | 3,598 | 3,598 | 3,598 | 3,598 |

# Mechanisms (2)

| | Hospitals Characteristics | |
|---|---|---|
| | **Fixed Effects** | **Volume Levels** |
| | **Low** | **Low** |
| *Distance* | 0.247323 | 0.351241** |
| | (0.161053) | (0.171130) |
| | **High** | **High** |
| *Distance* | 0.4765*** | 0.03364 |
| | (0.17237) | (0.18779) |
| Difference | 0.229175** | -0.317598** |
| | (0.108655) | (0.128496) |
| Observations | 38,790 | 38,790 |
| Municipalities | 3,985 | 3,985 |

# Conclusions

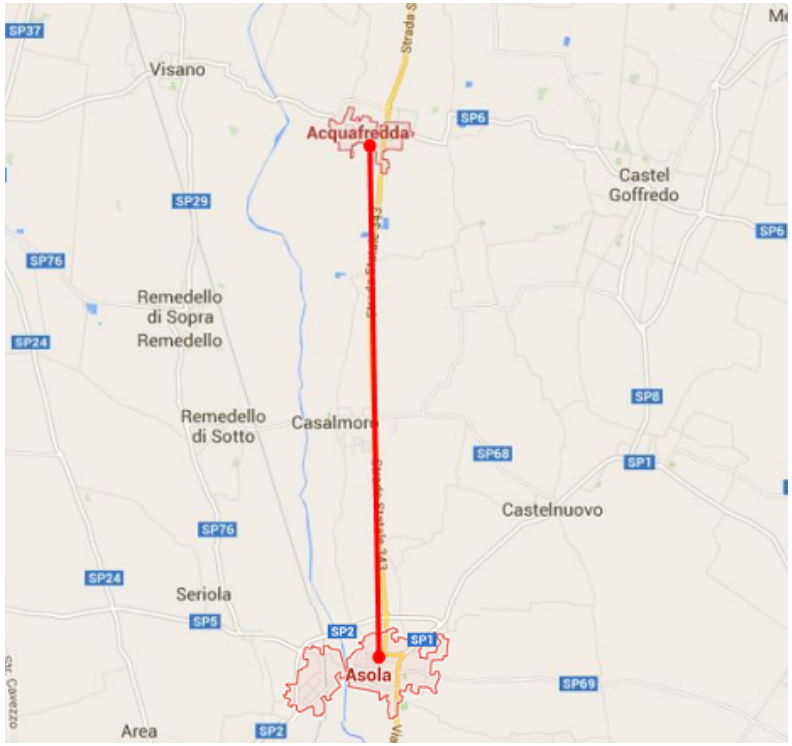
We provide a new assessment of the link between hospital proximity and mortality rates with reference to emergency cares

An exogenous variation in hospital proximity increases road-traffic fatality rates (but it does not decrease maternal screenings)

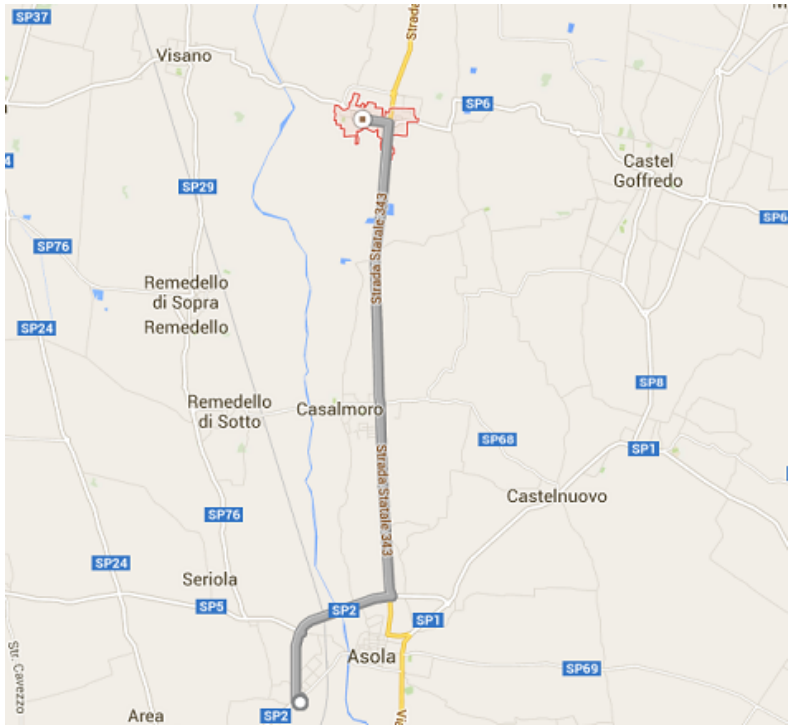
This effect is stronger than the OLS correlation because more deadly accidents tend to happen closer to hospitals

A more effective ES can partially reduce the impact of decreasing proximity

# Distance




[a]




[b]

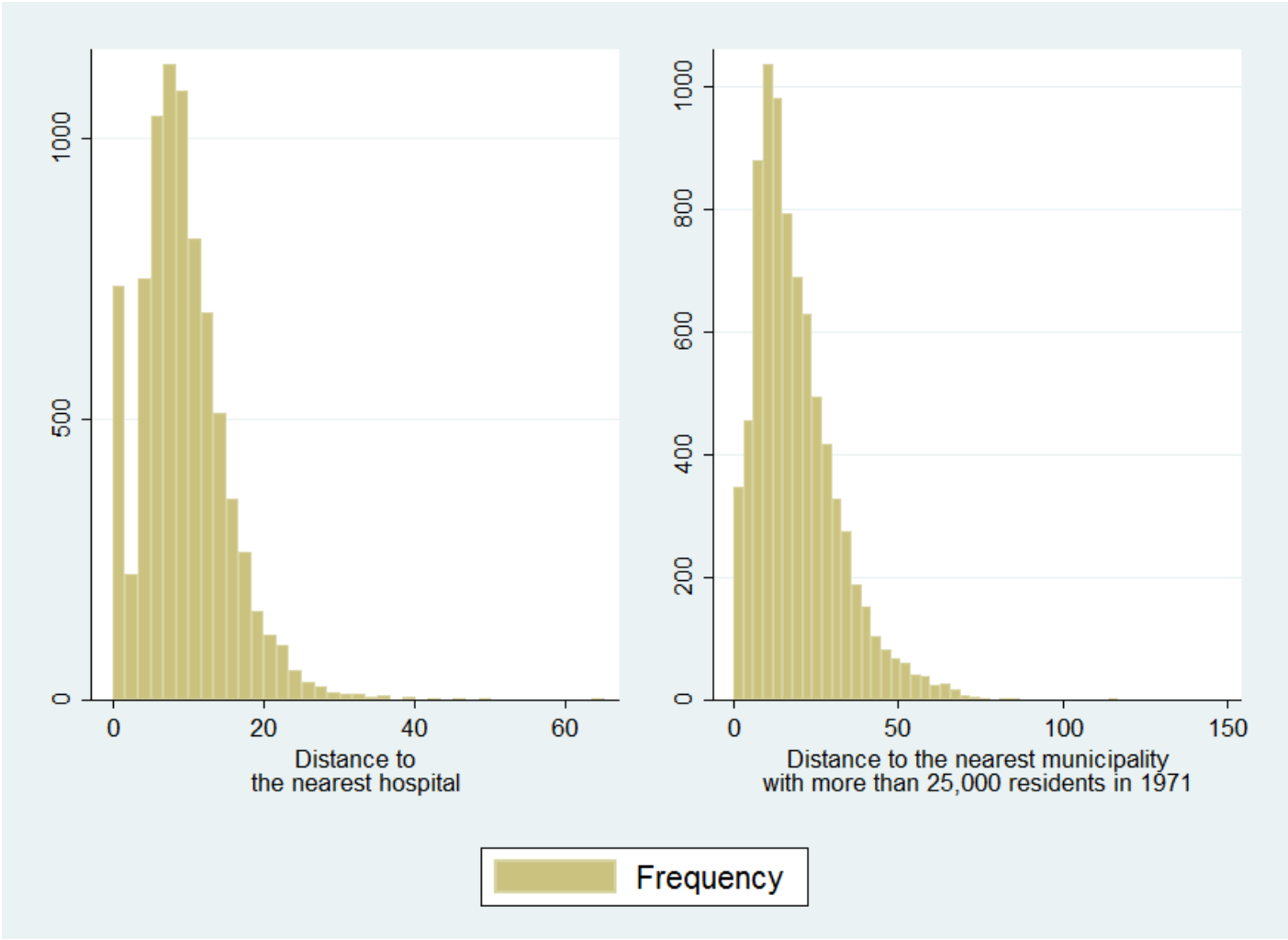
back

# Shifts around the 25,000 threshold

| | | Population: 25,000-50,000 | | |
|---|---|---|---|---|
| **Population** | **Year** | **1981** | **1991** | **2001** |
| **10,000-25,000** | **1971** | None | None | None |
| | **1981** | | None | None |
| | **1991** | | | None |

back

# Distance Distribution




back

# Descriptive Stats

back

| Variable | All | No Hosp + Pop1971<50,000 | Pop1971<25,000 | Pop1971<25,000 + Nearest<50,000 | Pop1971<25,000 + Nearest<50,000 + No Hosp |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Fatality Rate | 6.046 | 6.357 | 6.236 | 6.519 | 6.687 |
| | (17.408) | (18.153) | (17.794) | (18.521) | (19.094) |
| Distance | 8.560 | 9.648 | 8.927 | 8.821 | 9.625 |
| | (5.562) | (5.400) | (4.934) | (5.548) | (5.088) |
| Distance 1971 | 18.471 | 17.621 | 18.106 | 17.717 | 17.457 |
| | (12.350) | (11.982) | (12.007) | (12.033) | (11.978) |
| Population density | 348.741 | 308.453 | 301.387 | 326.133 | 320.37 |
| | (693.712) | (559.866) | (623.087) | (641.207) | (655.733) |
| Income | 16,399 | 16,252.88 | 16,303 | 16,069 | 16,011.34 |
| | (3,859.57) | (3,820.376) | (3,830.16 ) | (3,859.97) | (3,874.01) |
| Plain | 54.501 | 54.182 | 53.59 | 56.124 | 56.607 |
| | (49.797) | (49.871) | (49.825) | (49.624) | (49.562) |
| Partially mountain | 8.866 | 7.571 | 8.304 | 8.128 | 7.389 |
| | (28.425) | (27.594) | (26.455) | (27.327 ) | (26.159) |
| Totally mountain | 36.634 | 38.246 | 38.106 | 35.748 | 36.004 |
| | (48.181) | (48.599) | (48.565) | (47.926) | (48.002) |
| Coastal | 9.291 | 7.469 | 8.093 | 9.734 | 8.971 |
| | (29.03) | (26.289) | (27.273) | (29.642) | (28.577) |
| Observations | 81,212 | 71,900 | 77,473 | 42,296 | 38,790 |
| Municipalities | 7,954 | 7,219 | 7,665 | 4,266 | 3,985 |

Notes: *Distance* and *Distance* 1971 are in kilometers. On the overall sample, the average *Distance* in miles is 5,319 (sd 3,456) and the average 1971 in miles is 10,949 (sd 7,764). *Income* is in per capita 2012 euro.