



Spatial risk analysis of out-of-hospital cardiac arrests

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Background

- Improving survival from out-of-hospital cardiac arrest (OHCA) is an important public health challenge.
- Survival chances increase drastically with quick resuscitation.
- Dispatch apps send volunteers to perform CPR or to fetch an automated external defibrillator (AED).
- To improve defibrillation by volunteers, AEDs must be available nearby.
- To place them effectively (using OR methods), we need to understand *where* and *when* OHCA occur.

Objective

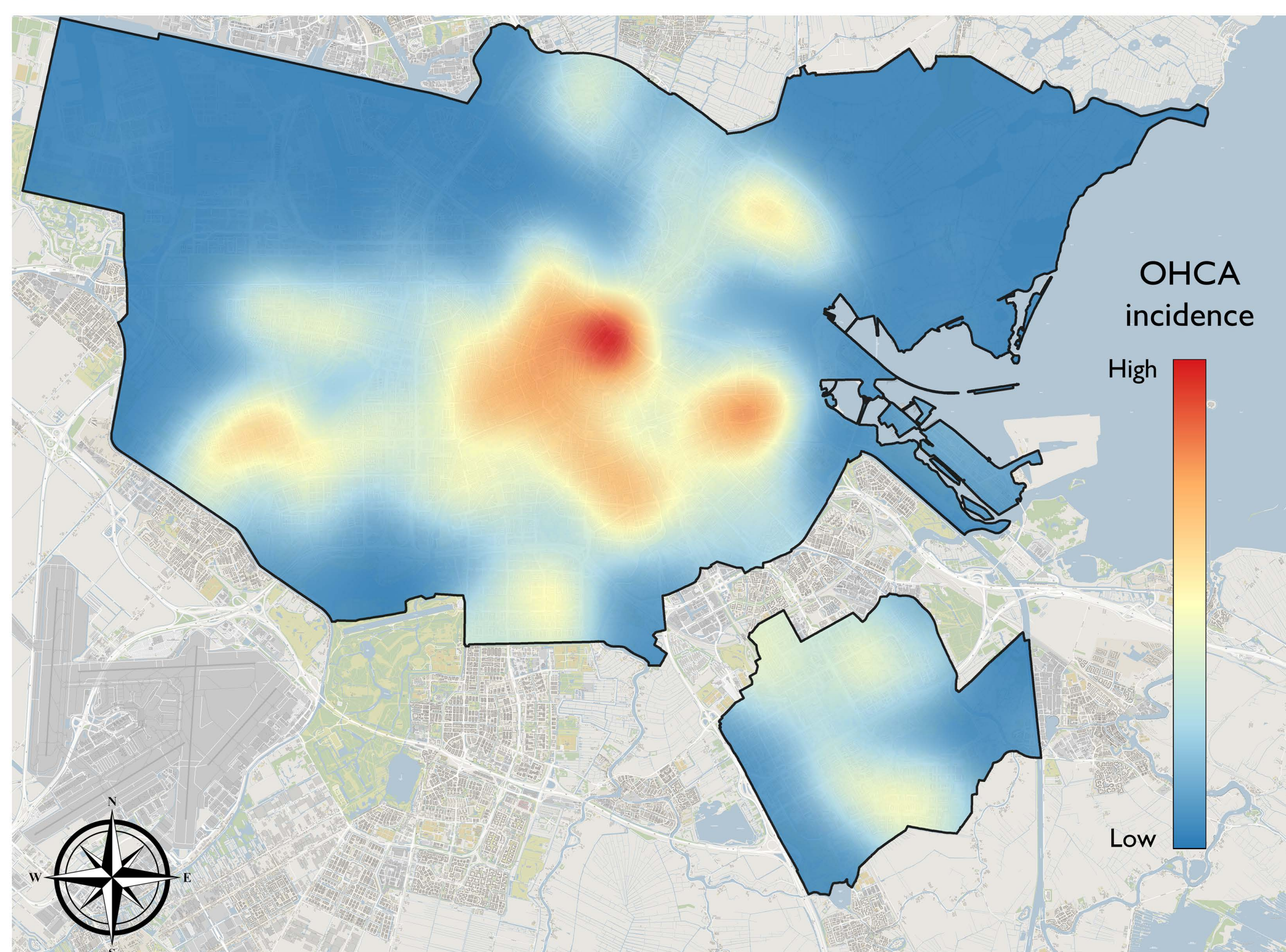
- To develop models to analyze spatial and spatiotemporal OHCA incidence, and to identify areas of high risk.

Data

- Amsterdam Resuscitation Studies (ARREST)
- Amsterdam, the Netherlands, 2006-2016, $n = 2901$

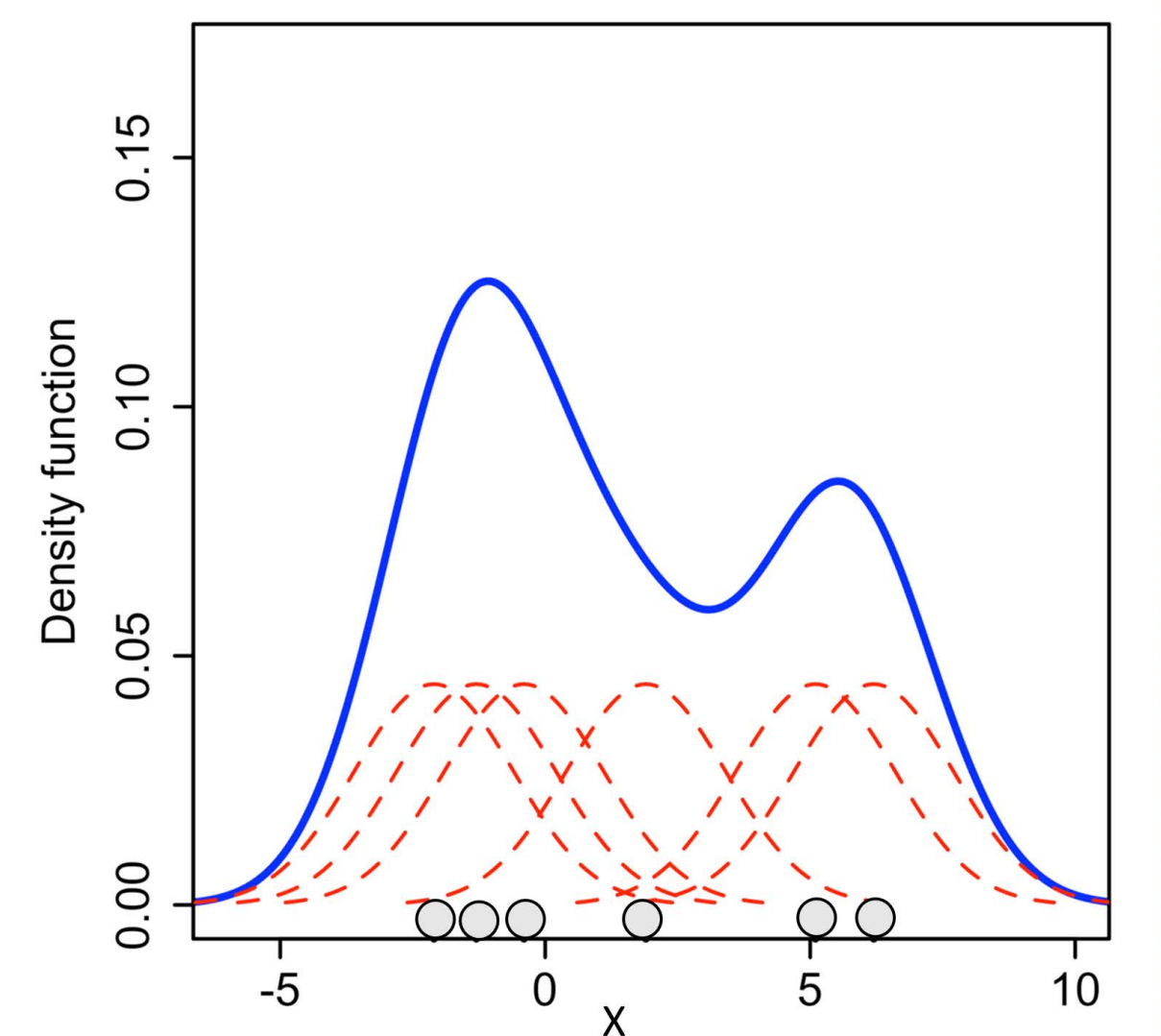
Results

(1) Spatial distribution of OHCA incidence



Methods

- We used kernel density estimation (KDE), which is a statistical smoothing method.
- Smoothing is controlled by a bandwidth parameter.



(1) Spatial distribution

- 2D KDE (X, Y): Gaussian kernels
- Bandwidth: bootstrapped Mean Integrated Squared Error

(2) Spatiotemporal distribution

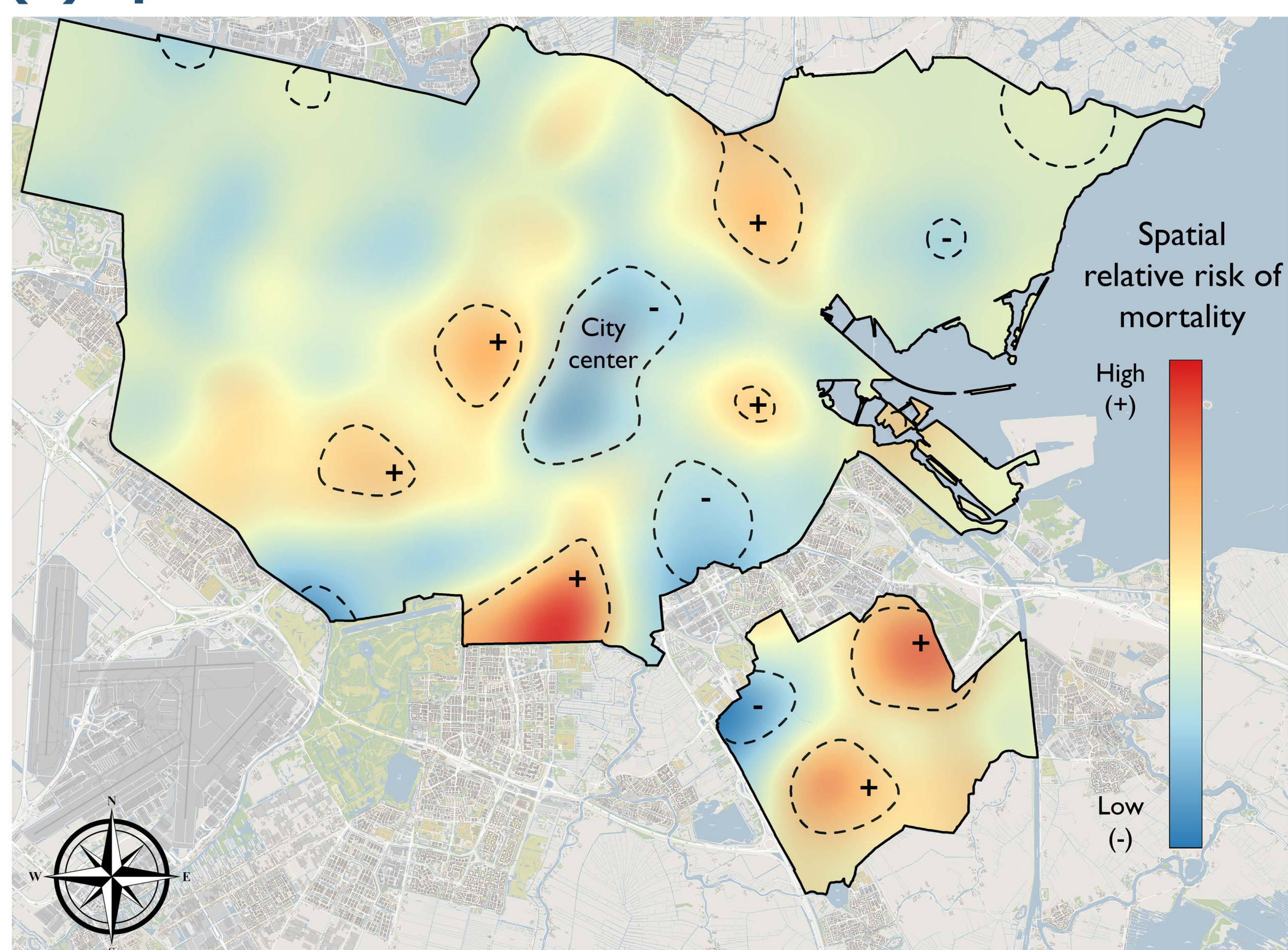
- Time dimension is circular (00:00-24:00)
- Von Mises kernel is a Gaussian on a circle, $\theta \in [-\pi, \pi]$
- 3D KDE (X, Y, Θ): Model (1) + Von Mises kernel for time
- Temporal bandwidth: trigonometric moments method¹

(3) Spatial relative risk

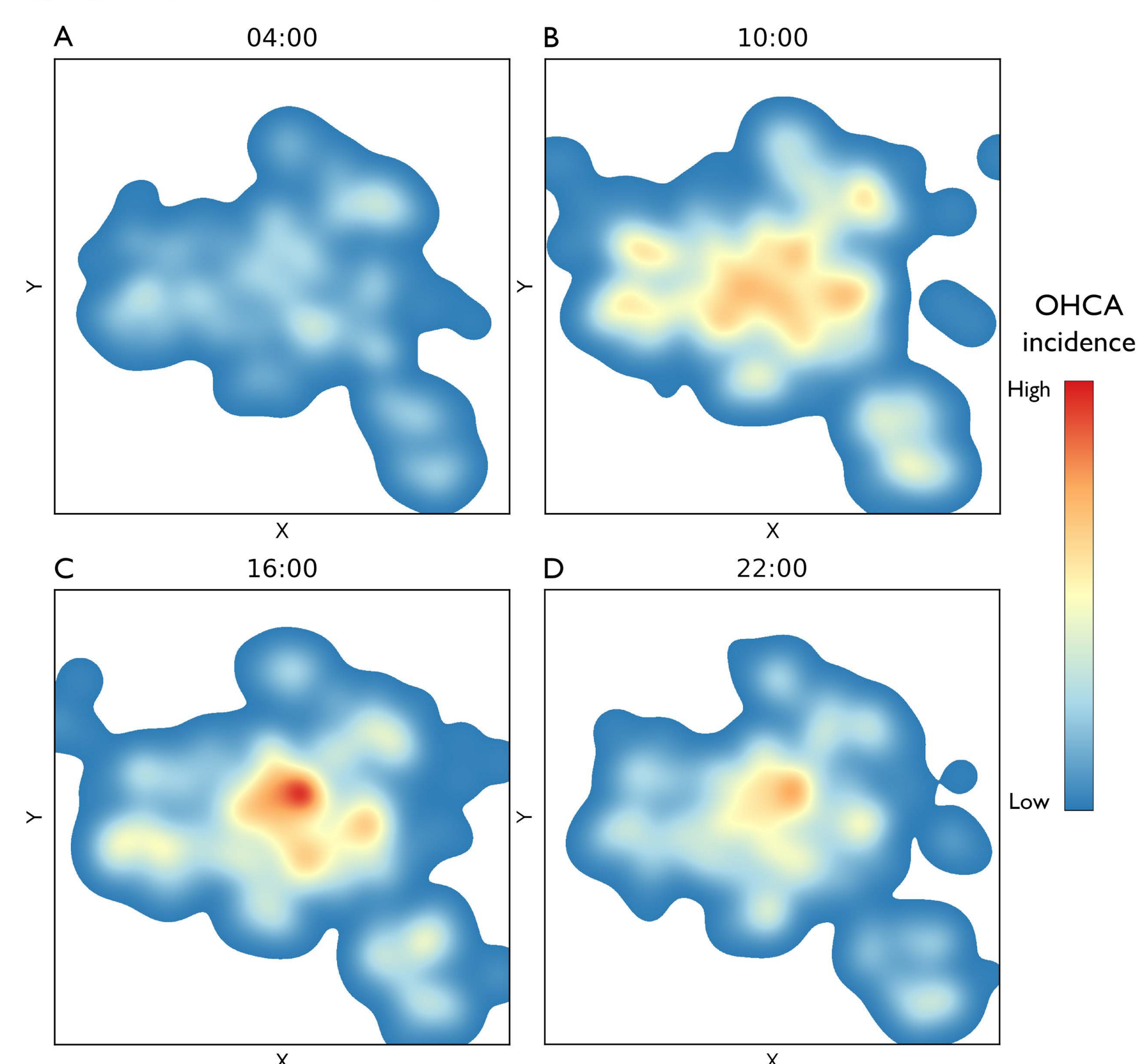
- Ratio of spatial KDEs of non-survivors & survivors

¹Taylor CC. Automatic bandwidth selection for circular density estimation. Computational Statistics & Data Analysis. 2008

(3) Spatial relative risk



(2) Spatiotemporal OHCA distribution



Risk area	n	Survival	CPR	AED	Median AED connection time (IQR)
High (+)	562	9%	66%	48%	9:17 (7:10-11:53)
Neutral	1907	20%	69%	47%	9:02 (7:00-11:45)
Low (-)	432	36%	78%	52%	7:41 (5:54-10:06)

- Survival is significantly lower in the identified high risk areas.
- OHCA in high risk areas receive CPR less often compared to those in low risk areas.
- Median AED (or EMS) connection time is more than 1½ minutes longer in the high risk areas than in the low risk areas.

Conclusions

- KDE can help visualize OHCA risk and identify areas of interest.
- Spatial and spatiotemporal models can be used as input to optimization models.
- Engagement with local stakeholders and public health experts is crucial in further understanding disparities between areas.