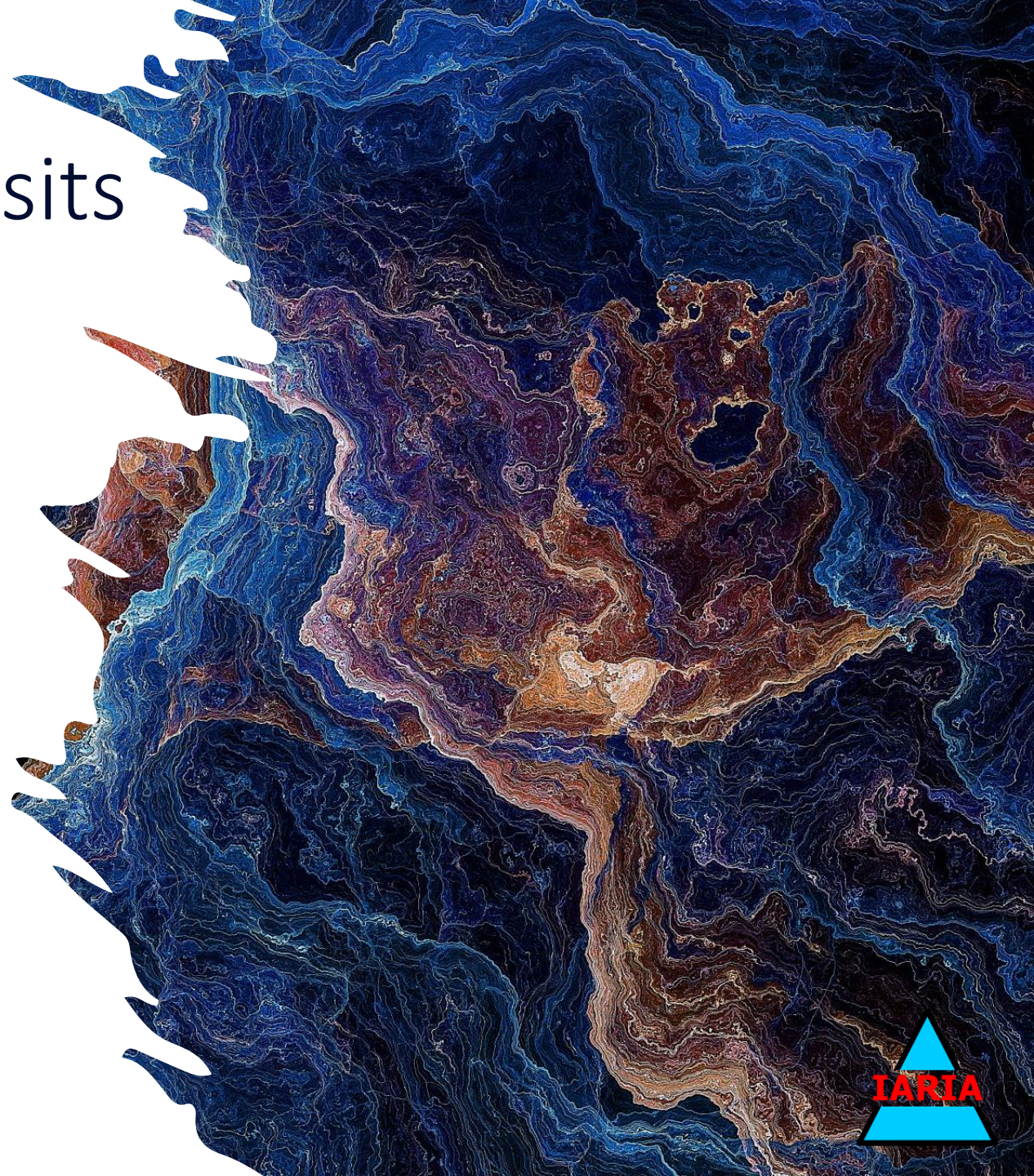
Predictive Analytics for Emergency Department Visits Based on Local Short-Term Pollution and Weather Exposure

Isabella Della Torre [1,2], **Ismaela Avellino** [1,3],
Francesca Marinaro [1], Andrea Buccoliero [1],
Antonio Colangelo [1]

1 GPI SpA Trento, Italy
2 email: isabella.dellatorre@gpi.it
3 email: ismaela.avellino@gpi.it



Isabella Della Torre

She received the master's degree in Mathematical Engineering from Politecnico di Milano, Italy in 2023. She is a researcher at GPI's Research & Development department.

Her research interests are machine learning, mathematical modelling and computational techniques.

In her free time, she enjoys travelling and hiking.

Ismaela Avellino

She received the master's degree in Biomedical Engineering from Università Politecnica delle Marche, Italy in 2022. She is a researcher at GPI's Research & Development department.

Her research interests are knowledge graphs, machine learning and artificial intelligence.

In her free time, she enjoys travelling and art.

R&D Department: a few current projects

Population Health Management

- Algorithmic Solutions and Virtual Care Technology applied on clinical big data

One Health

- Using AI to predict outbreaks of diseases that can affect humans, animals, and ecosystems, crucial for early warning systems and for preventing or mitigating epidemics and pandemics

Vocal biomarkers analysis

- For diagnosis and pathology monitoring purposes, focusing on fields like neurodegenerative diseases and emotional health

Virtual Care

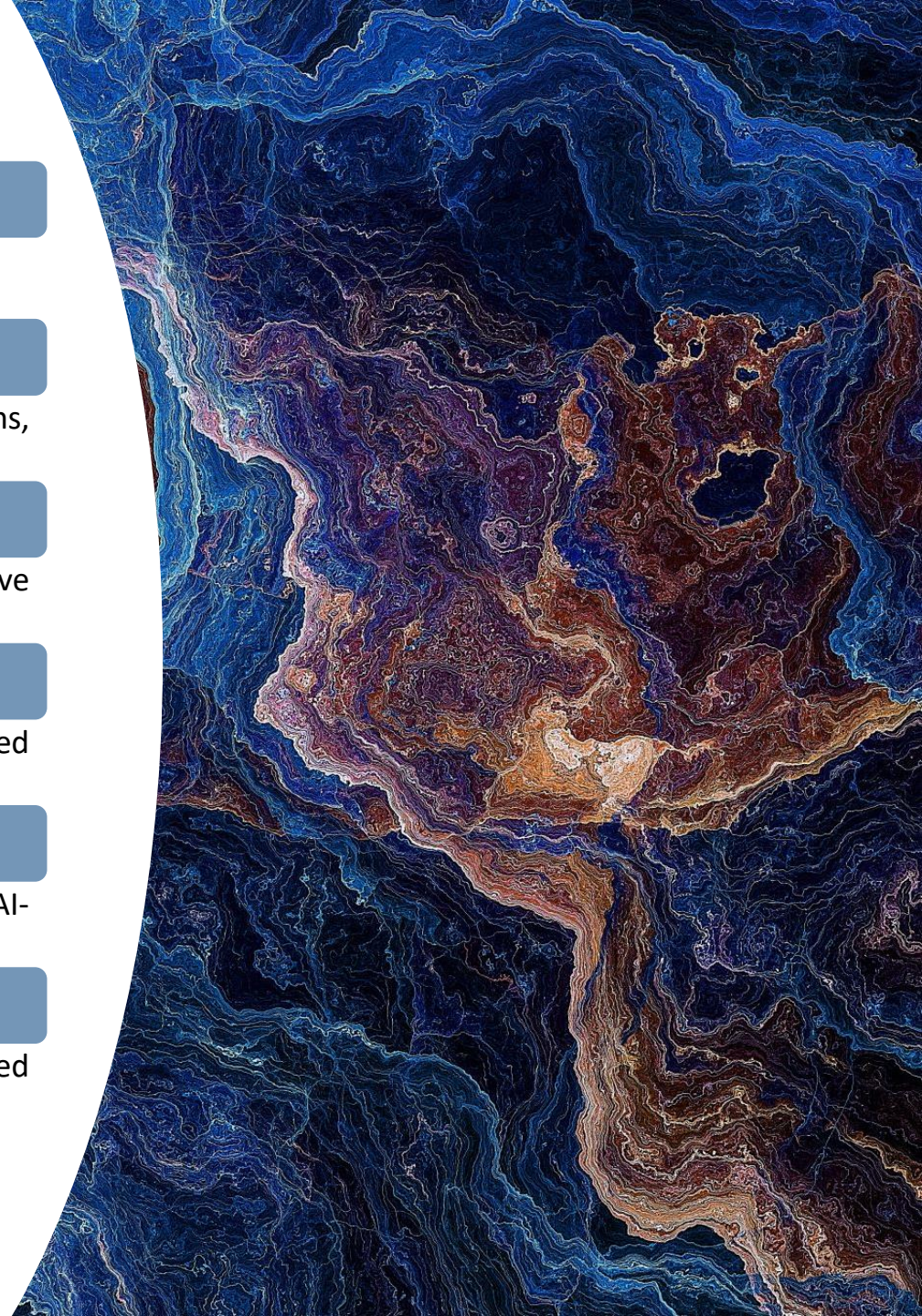
- Telehealth, Teleconsultation, Telemonitoring, Telerehabilitation, Patient Portal, Augmented Telemedicine, Digital Therapeutics, …

Artificial Intelligence

- Topics include Predictivity in Augmented Epidemiology, NLP, Automatic Pattern Recognition, AI-supported Proactive Medical Centers

Diagnostics, Laboratory and Blood Bank Information Systems

- Application of AI to increase accuracy and efficiency in diagnostics through automated processing of laboratory tests or analysis of blood samples



GPI
The Healthcare Partner

“Care shouldn’t start in the emergency room”

James Douglas

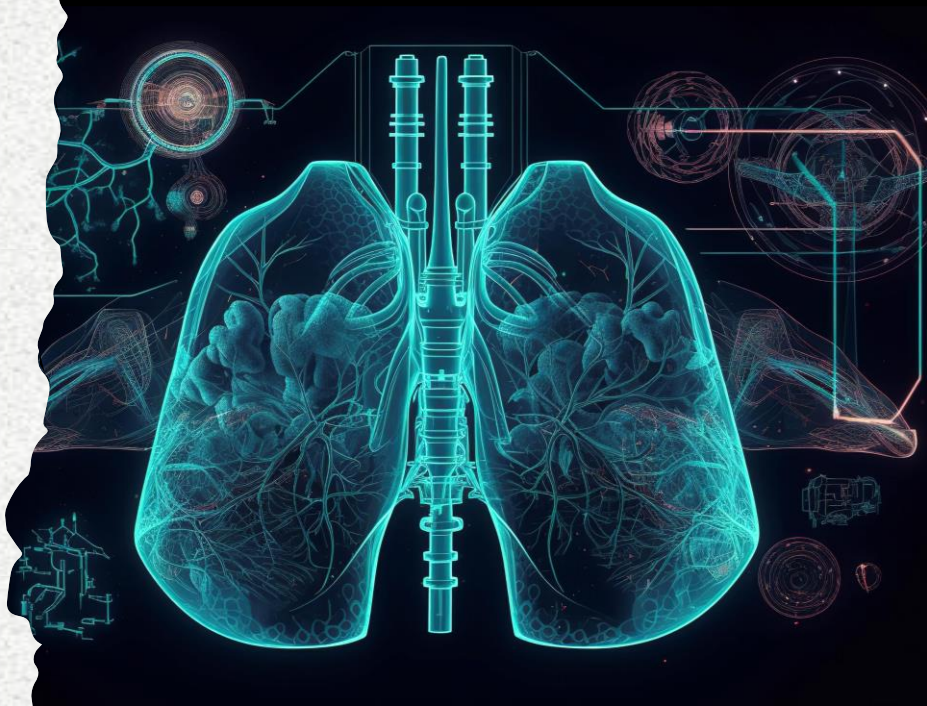
The Healthcare Partner

Our aim

ER historical data

Integration of pollution and weather data

Predictive analysis of visitors' volume based on local environment



The Healthcare Partner

Data

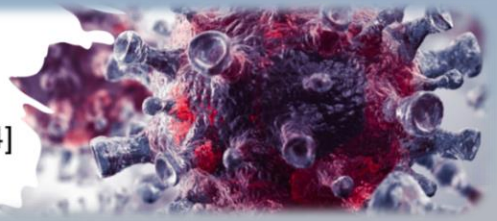
Brescia (2018-2022)

ER accesses

Environment

Hypermeteo
Climate & weather grids

COVID-19 pandemic
(2020 and 2021):
decrease in ER accesses [23, 24]



One of the most polluted
areas in Europe [28]

Data

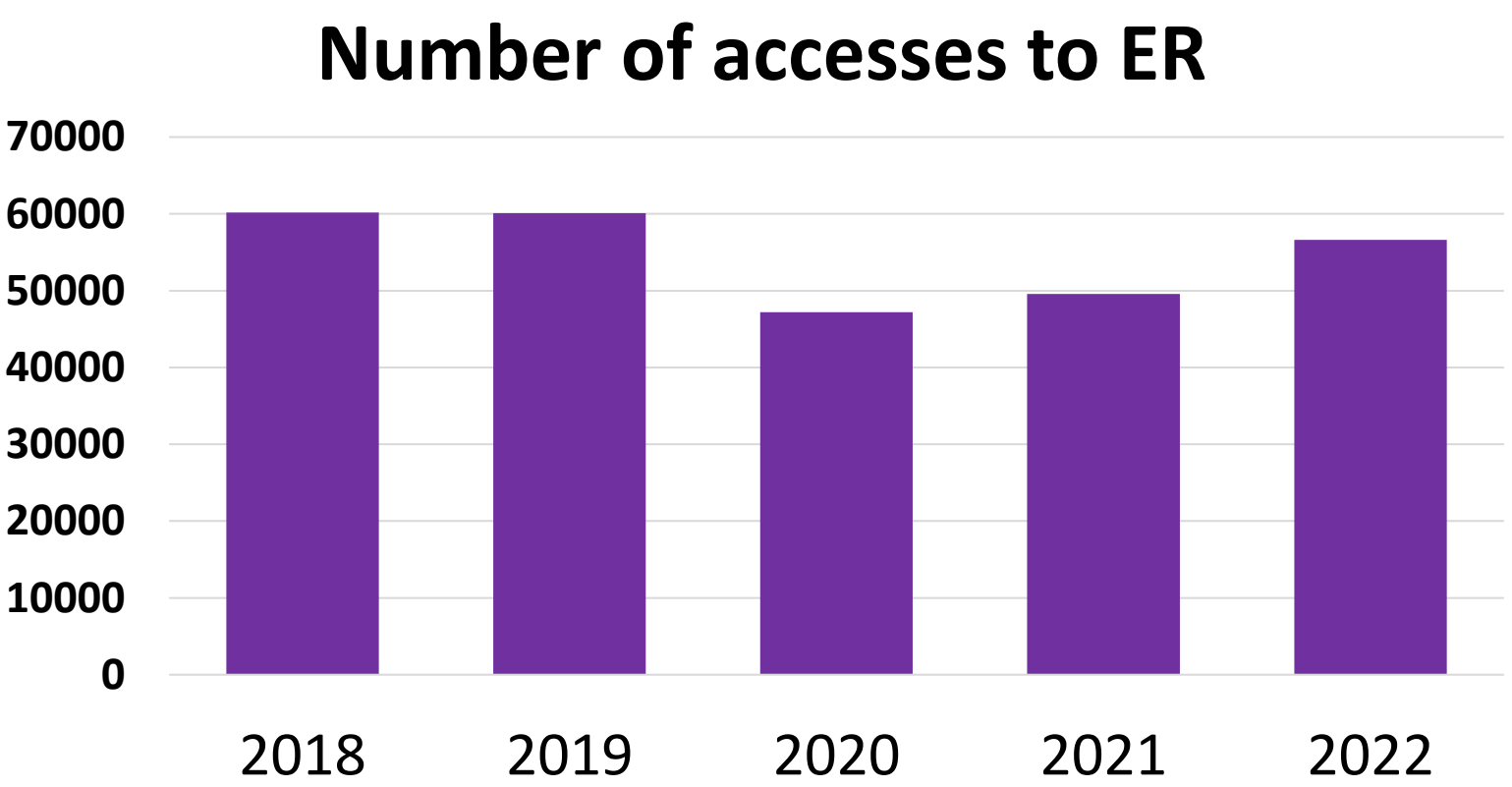
Brescia (2018-2022)

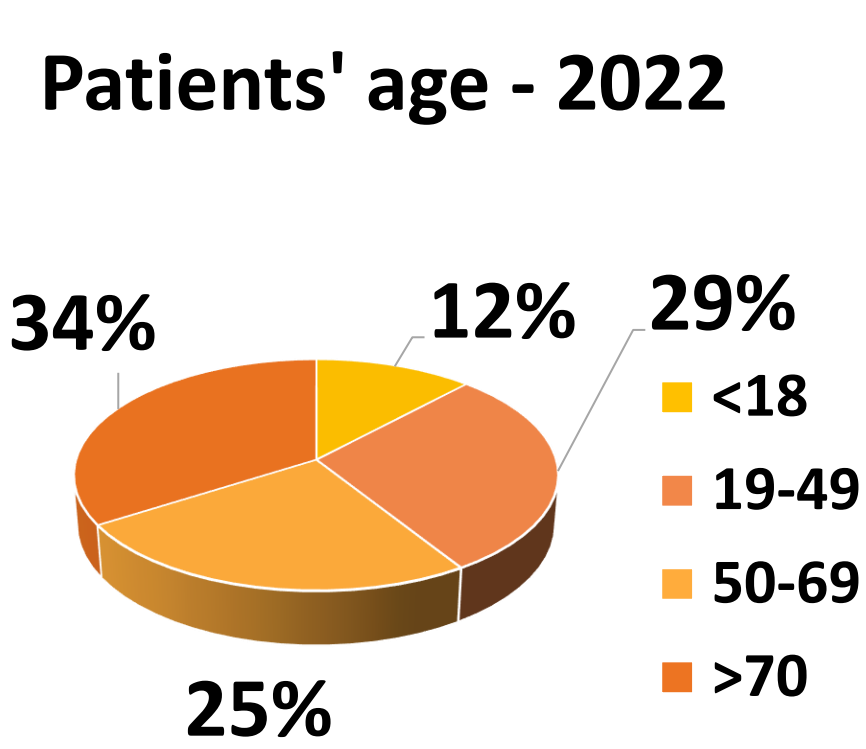
ER accesses

Environment

Hypermeteo
Climate & weather grids

Clinical data





The Healthcare Partner

After pre-processing:
daily number of accesses or hospitalisations to the ER, limited to those patients coming **only from the city of Brescia** + rolling mean of the daily accesses computed on a seven-day window

Environmental data

Temperature
(T_{min} and T_{max} [°C])

Humidity
(RH_{min} and Rh_{max} [%])

Precipitations
(Prec [mm])

PM_{10} and $PM_{2.5}$ [µg/m^3]

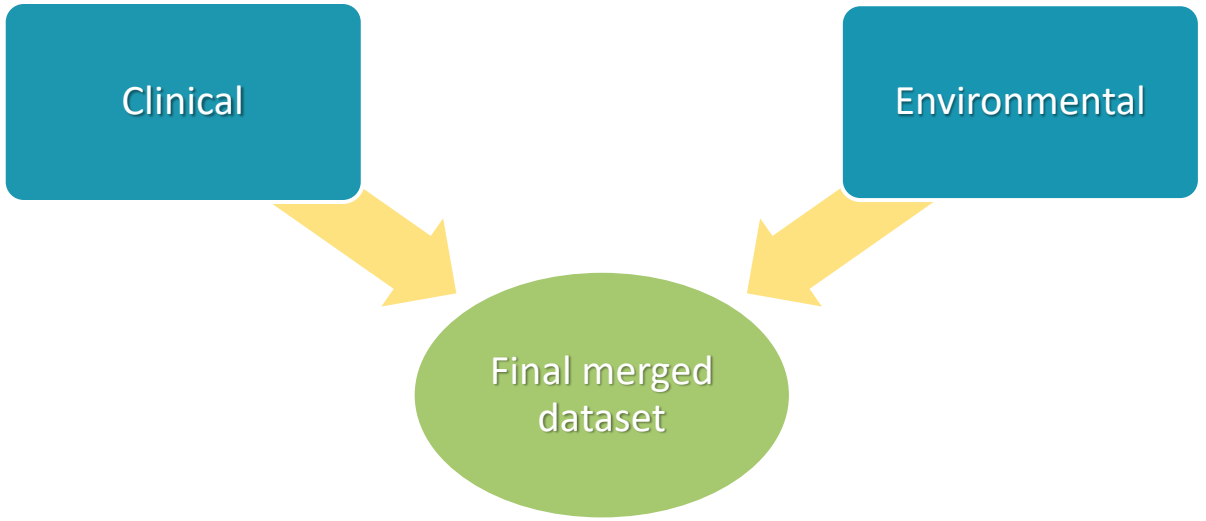
NO_x , SO_2 and O_3 [µg/m^3]

Total solar irradiance (SSW_{tot} [Wh/m^2])

The Healthcare Partner

After pre-processing [30]:
each variable has been labelled with the zip code it refers to, so we have all same date data on one row

Case studies - predictive algorithms



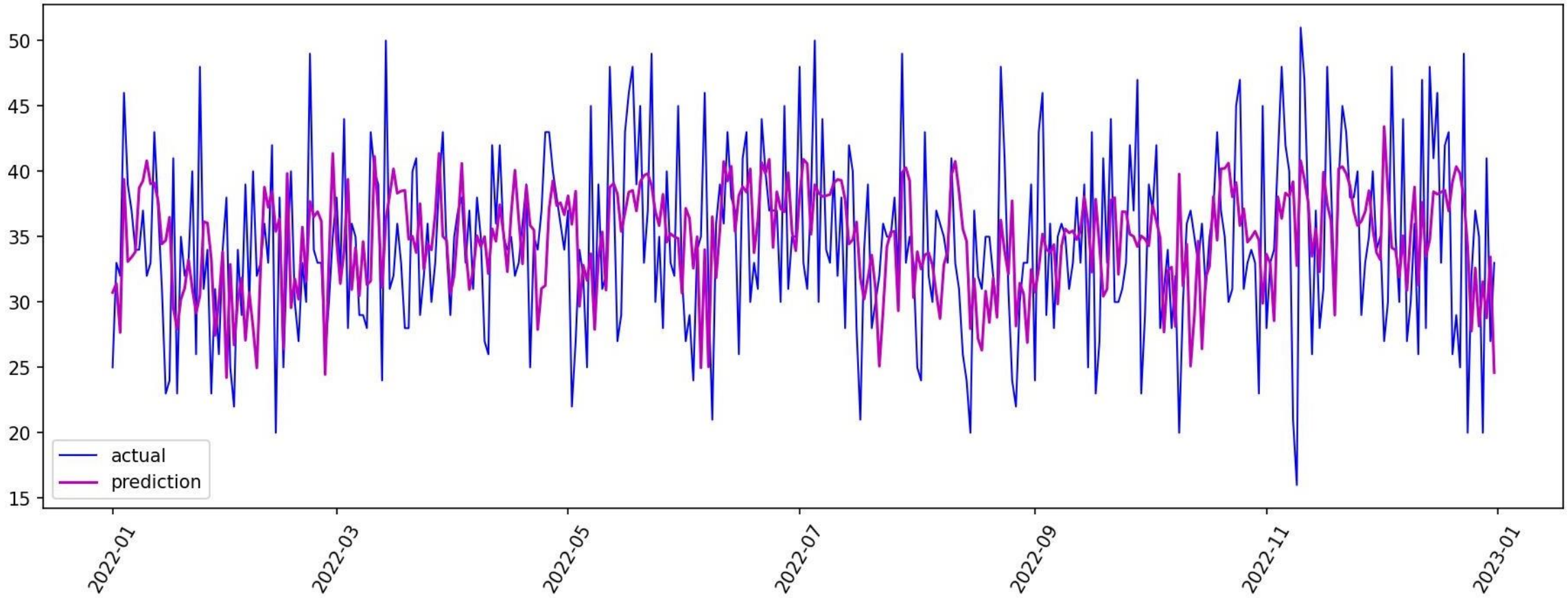
A	1) Final pre-processed accesses dataset 2) 1-day and 5-day lagged data 3) Only on the 2 most important features, as computed by the model
B	Analogous to A, but the rolling mean feature was discarded
C	1) 1-day lagged hospitalisation data without rolling mean – cardiovascular patients 2) Only on the 2 most important features
D	Analogous to C, but on data belonging to patients affected by respiratory diseases

gpi
The Healthcare Partner

Random Forest [29]

MAE = 5.1

Acc = 84.42 %



Case study A2

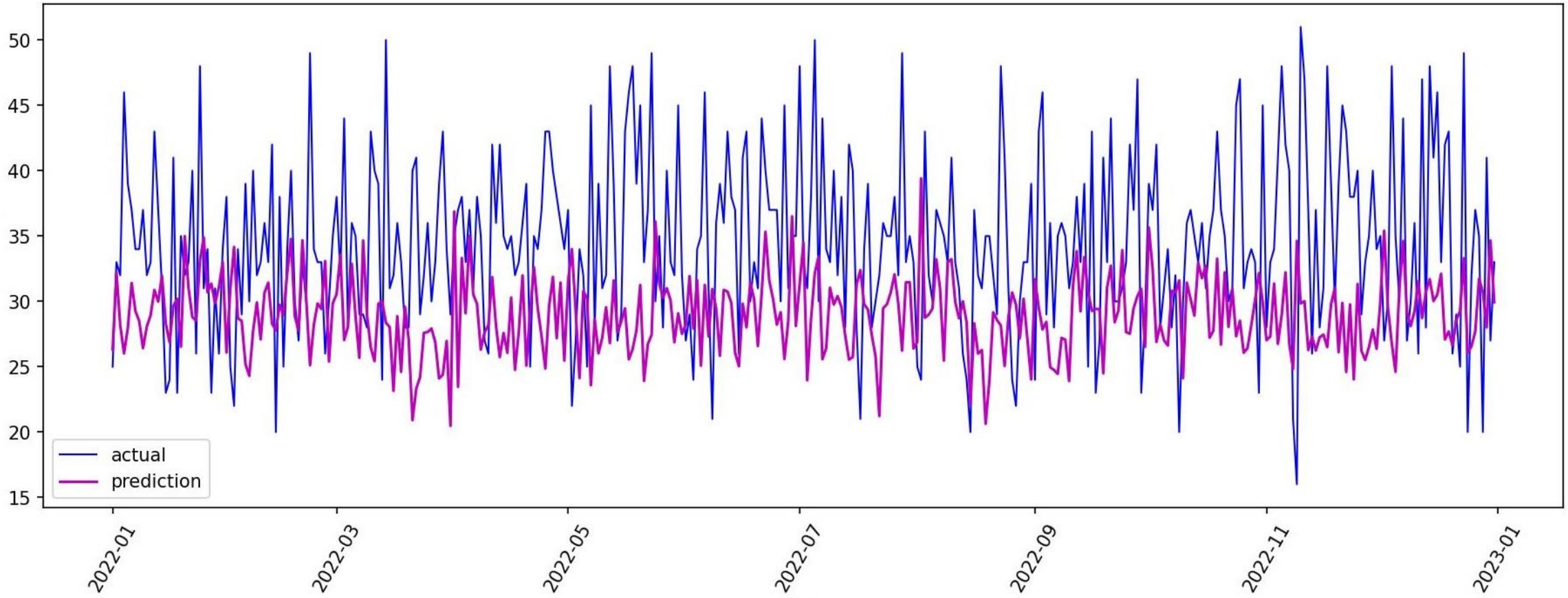
1-day lag

The Healthcare Partner

Random Forest

MAE = 6.33

Acc = 82.44 %



Case study B

1-day lag without rolling mean

The Healthcare Partner

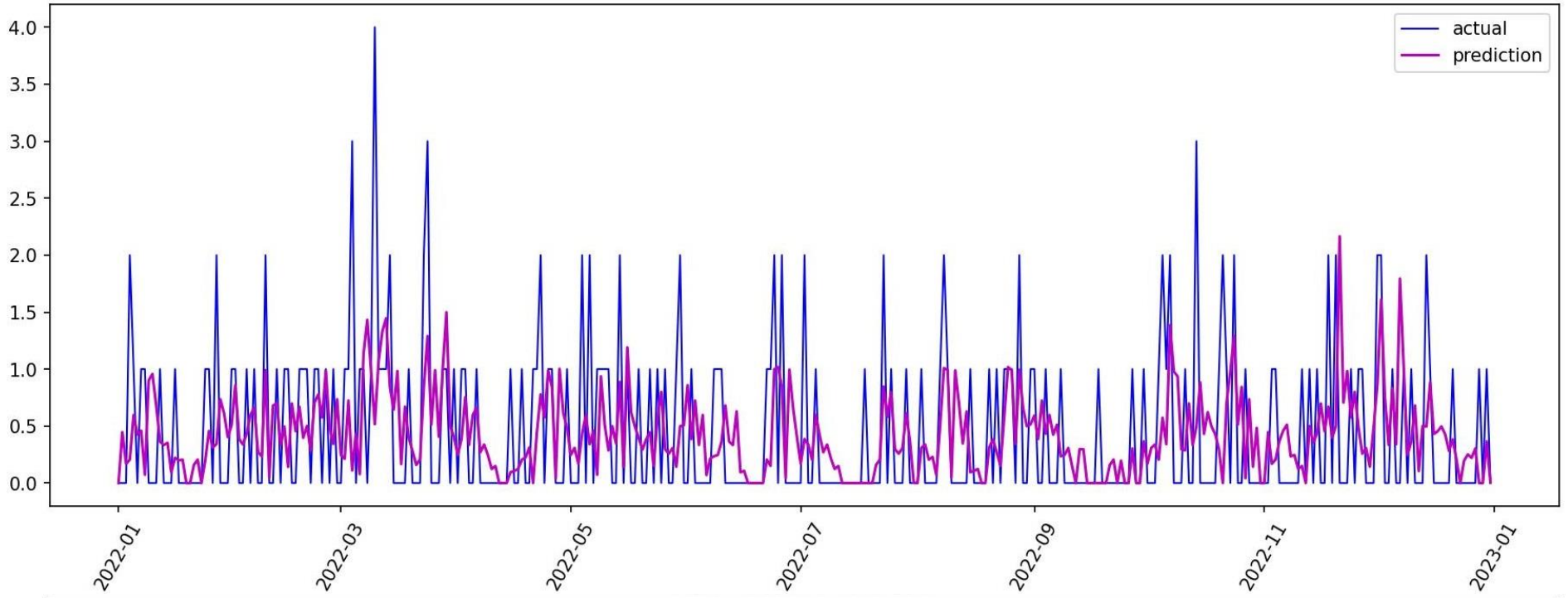
Case study C1

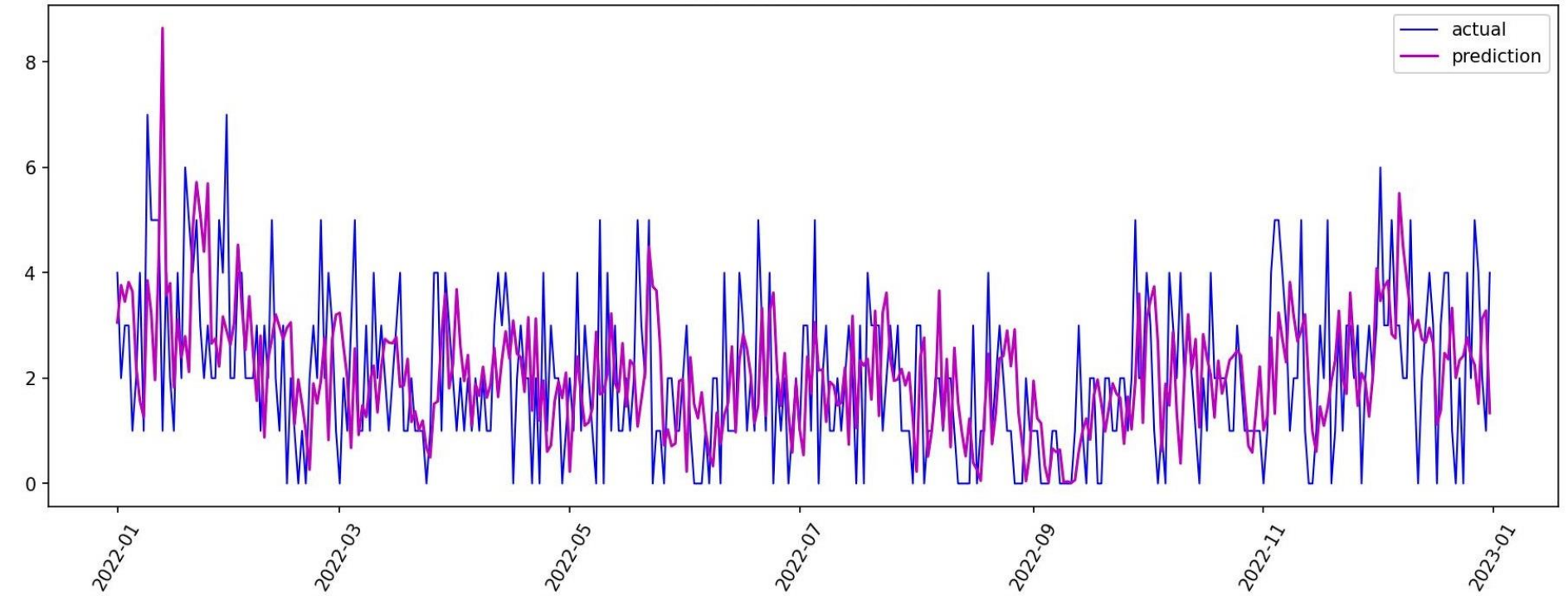
MAE = 0.51

Random Forest

MAE = 1.09

Case study D1

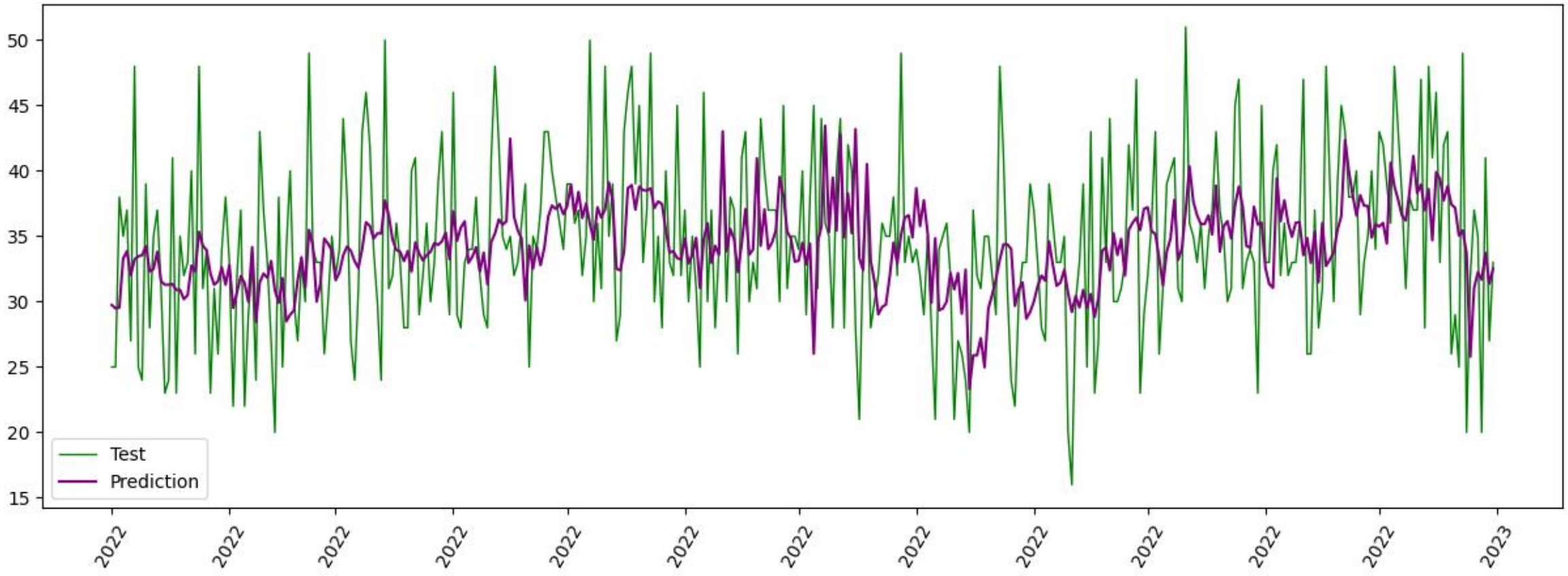




The Healthcare Partner

ARIMA [32]

MAPE = 15% MSE = 39.5 RMSE = 6.3



Case study A1 (just the pre-processed final dataset)

The Healthcare Partner

Additional remarks

Same-day data and 5-day lagged data: worsening or no improvement in results.

When reducing the dataset to only the two features computed to be the most important ones, RF behaves even less precisely.

Decrease in ER accesses due to COVID-19 in 2020 and 2021: attempt at training only on 2018 and 2019 data, but predictions did not become more precise.

The number of hospitalisations for specific pathologies is limited to a few people every day and, sometimes, even none.

Conclusion and future work

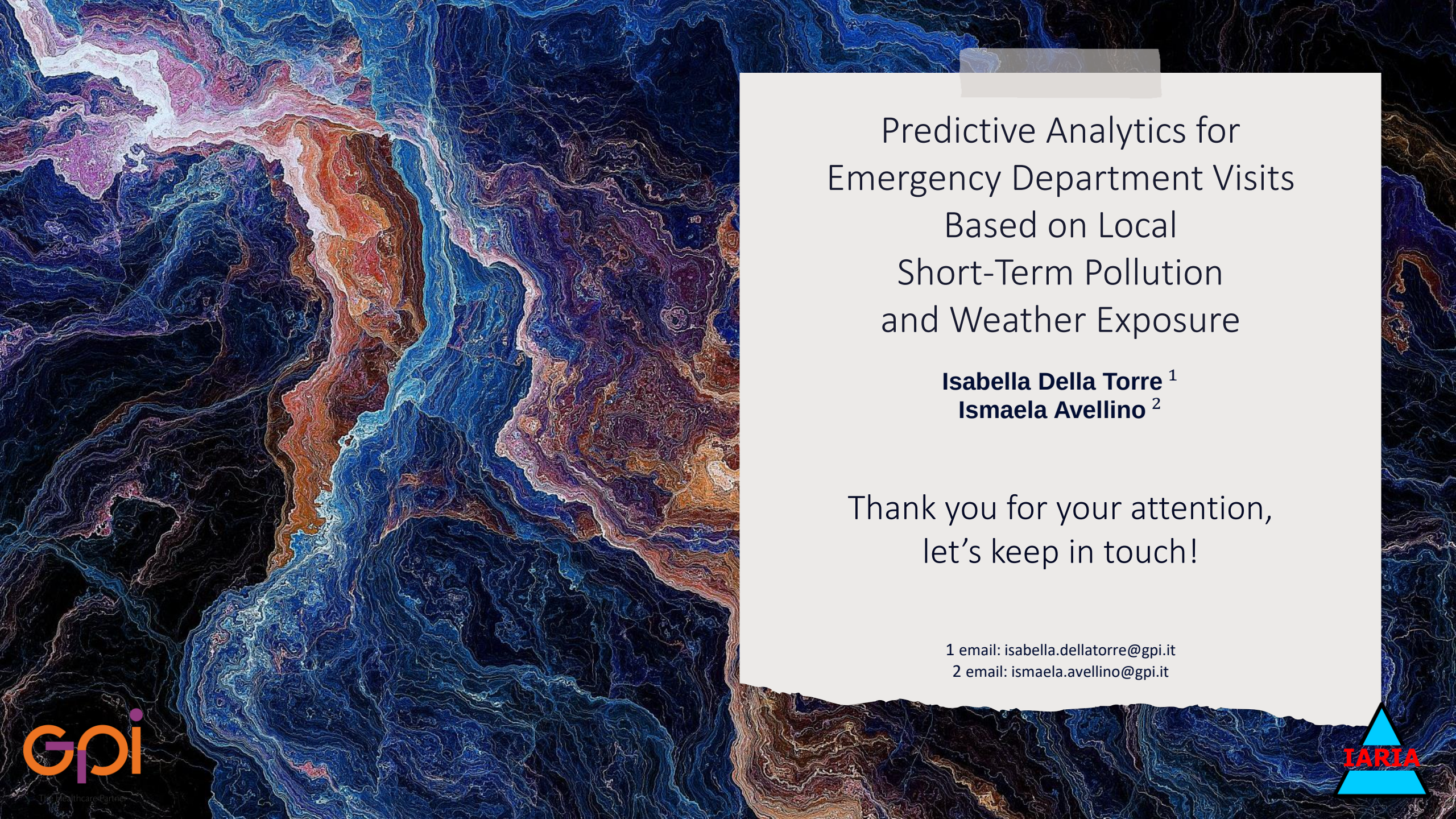
This work is a starting point towards the time-series analysis of historical and environmental data for the prediction of ER accesses and hospitalisations in a specific geographical area.

Results are not optimal but generally promising, even though they cannot be generalised.

Future developments will include data belonging to the entire province of Brescia and test other algorithms.

This may be the offset of a new way of managing ER, monitoring entire populations and geographical areas, enabling a smart real-time predictive analysis able to improve the quality of healthcare and people's quality of life.

GPI
The Healthcare Partner



Predictive Analytics for Emergency Department Visits Based on Local Short-Term Pollution and Weather Exposure

Isabella Della Torre [1]
Ismaela Avellino [2]

Thank you for your attention,
let's keep in touch!

1 email: isabella.dellatorre@gpi.it
2 email: ismaela.avellino@gpi.it

gpi
The Healthcare Partner

IARIA

Reduced bibliography

[…]
[16] R. D. Brook et al., “Particulate matter air pollution and cardiovascular disease: an update to the scientific statement from the American Heart Association”, Circulation, vol. 121, no. 21, pp. 2331–2378, 2010.
[17] F. Dominici et al., “Fine particulate air pollution and hospital admission for cardiovascular and respiratory diseases”, Jama, vol. 295, no. 10, pp. 1127–1134, 2006.
[…]

[23] F. Tartari, A. Guglielmo, F. Fuligni, and A. Pileri, “Changes in emergency service access after spread of COVID-19 across Italy”, Journal of the European Academy of Dermatology and Venereology, vol. 34, no. 8, p. e350, 2020.
[24] T. Ferrari, C. Zengarini, F. Bardazzi, and A. Pileri, “In-depth, single-centre, analysis of changes in emergency service access after the spread of COVID-19 across Italy”, Clinical and Experimental Dermatology, vol. 46, no. 8, pp. 1588–1589, 2021.

[…]

[28] S. Khomenko et al. “Premature mortality due to air pollution in European cities: a health impact assessment”, The Lancet Planetary Health, vol. 5, no. 3, pp. e121–e134, 2021
[29] https://scikit-learn.org/stable/modules/generated/sklearn.ensemble.RandomForestRegressor.html [Retrieved online: January 2024].
[30] https://towardsdatascience.com/random-forest-in-python-24d0893d51c0 [Retrieved online: January 2024].
[…]
[32] https://alkaline-ml.com/pmdarima/modules/generated/pmdarima.arima.autoarima.html [Retrieved online: January 2024].

Most images downloaded from Vecteezy’s archive, while others freely public on Google Images.
Pollution icons by callorine and SUPRIYANTO YANTO, downloaded from the noun project on February 2024.

The Healthcare Partner