FHIR PIT: an open software application for spatiotemporal integration of clinical data and environmental exposures data

Hao Xu
University of North Carolina at Chapel Hill

Steven Cox
University of North Carolina at Chapel Hill

Lisa Stillwell
University of North Carolina at Chapel Hill

Emily Pfaff
University of North Carolina at Chapel Hill

James Champion
University of North Carolina at Chapel Hill

Stanley C. Ahalt
University of North Carolina at Chapel Hill

Karamarie Fecho
University of North Carolina at Chapel Hill

Abstract

Background

Informatics tools to support the integration and subsequent interrogation of spatiotemporal data such as clinical data and environmental exposures data are lacking. Such tools are needed to support research in environmental health and any biomedical field that is challenged by the need for integrated spatiotemporal data to examine individual-level determinants of health and disease.

Results

We have developed an open-source software application—FHIR PIT (Health Level 7 Fast Healthcare Interoperability Resource Patient data Integration Tool)—to enable studies on the impact of individual-level environmental exposures on health and disease. FHIR PIT was motivated by the need to integrate patient data derived from our institution's clinical warehouse with a variety of public data sources on environmental exposures and then openly expose the data via ICEES (Integrated Clinical and Environmental Exposures Service). FHIR PIT consists of transformation steps or building blocks that can be chained together to form a transformation and integration workflow. Several transformation steps are generic and thus can be reused. As such, new types of data can be incorporated into the modular FHIR PIT pipeline by simply reusing generic steps or adding new ones. We have validated FHIR PIT in the context of a driving use case designed to investigate the impact of airborne pollutant exposures on asthma. Specifically, we replicated published findings demonstrating racial disparities in the impact of airborne pollutants on asthma exacerbations.

Conclusions

While FHIR PIT was developed to support our driving use case, the software can be used to integrate any type and number of spatiotemporal data sources at a level of granularity that enables individual-level study. We expect FHIR PIT to facilitate research in environmental health and numerous other biomedical disciplines.

Full Text

However, the manuscript can be downloaded and accessed as a PDF.

Figures
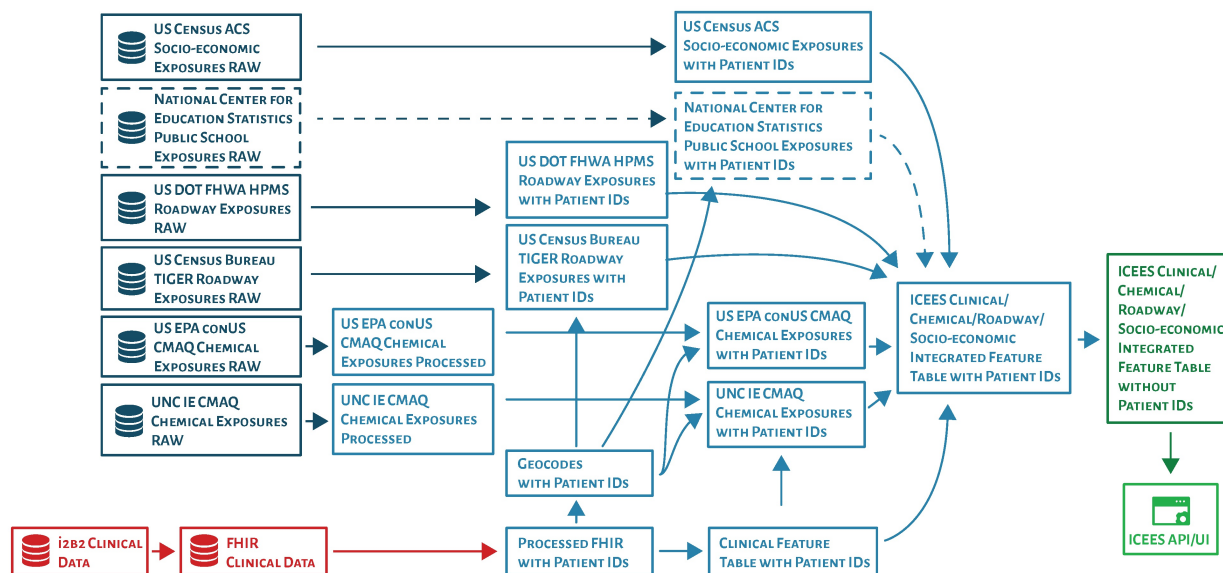
Figure 1

An overview of the integration steps embedded in the FHIR PIT software application
pipeline. API = application programming interface; FHIR = Health Level 7 Fast Healthcare
Interoperability Resource; ICEES = Integrated Clinical and Environmental Exposures Service;
UI = user interface; US Census ACS = US Census Bureau's American Community Survey; US
Census Bureau TIGER = US Census Bureau's Topologically Integrated Geographic Encoding
and Referencing system; US EPA conUS CMAQ = US Environmental Protection Agency's
conUS Community Multiscale Air Quality modeling data; US DOT FHWA HPMS = US
Department of Transportation, Federal Highway Administration, Highway Patrol Monitoring
System. Red color = sensitive, fully identified clinical data; dark blue color = public data on
environmental exposures; light blue color = secure, firewall - and Institutional Review
Board–protected integration steps; dark green color = de-identified, binned integrated
feature tables; light green color = ICEES OpenAPI. (Note that data from the National Center
for Education Statistics have not yet been integrated using FHIR PIT, but an approach is
under development to integrate data on school exposures with home exposures data and
clinical data, thereby addressing issues related to patient mobility and differential
exposures. A simplified version of the FHIR PIT pipeline was published in JAMIA
2019;26(1):1064–1073 and is reprinted in adapted form here with full permission from the
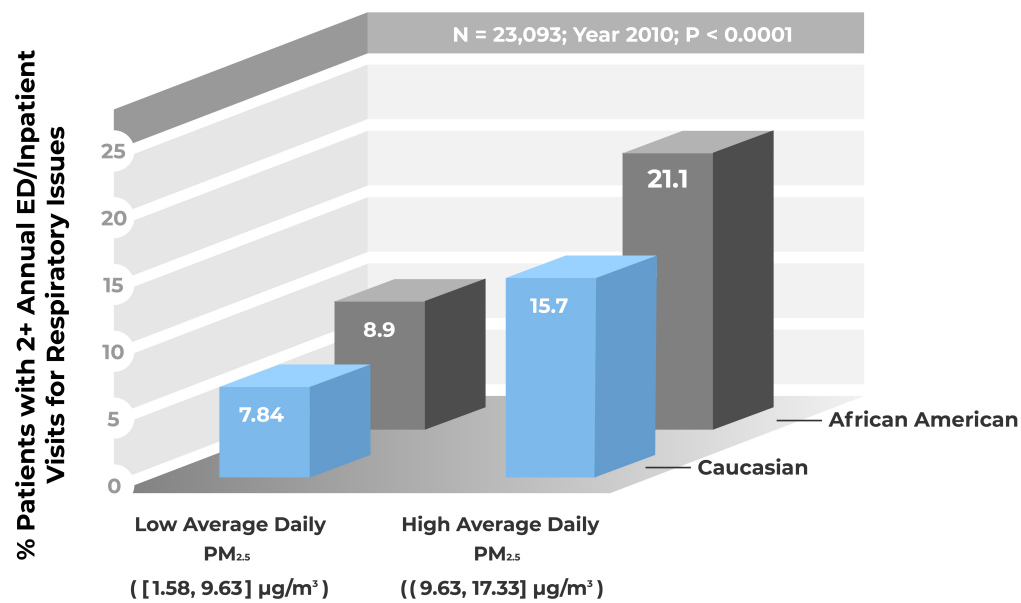
Figure 2

Racial disparities in the impact of airborne pollutant exposures on asthma exacerbations.

Sample sizes are: n = 6,379 African American patients; n = 13,176 Caucasian patients; and

n = 23,093 patients in overall cohort for year 2010. PM2.5 = particulate matter < 2.5-

microns in diameter. Levels of PM2.5 exposure were binned in FHIR PIT using pandas qcut

and expressed as ranges.