Ontology-based representation and analysis of kidney adverse events following vaccinations

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Background

The OHDSI Observational Medical Outcomes Partnership (OMOP) Common Data Model (CDM) is a widely adopted relational database model that supports interoperable analyses of disparate observational databases. However, the terms in the OMOP CDM lacks strong semantic relations. For example, the Condition in the OMOP CDM could be a natural disease course or an adverse event following vaccination or drug administering. In this study, we hypothesize that ontology-based semantic modeling, together with the usage of ontologies including the Human Phenotype Ontology (HP), Vaccine Ontology (VO) and Ontology of Adverse Events (OAE), could help address the Condition dilemma with better understanding of vaccine contributions and the following vaccine adverse events. Our study focused on the use case of analyzing one type of adverse event: Acute Kidney Injury (AKI) adverse event.

The Ontology of Precision Medicine and Investigation (OPMI) (https://github.com/OPMI/opmi) is a community-based open source biomedical ontology that represents entities and their relationships in the domain of precision medicine. OPMI supports the standard representation and analysis of precision medicine data and knowledge. In our last year's OHDSI symposium, we presented how to use OPMI to represent the OMOP CDM (He et al., 2018). Current OHDSI project extends last year's project and further illustrates our new ontology-based strategy.

OPMI representation of OMOP CDM

As shown in Fig. 1, OPMI adds new terms and links OMOP CMD elements. This model clearly shows the differences between natural disease courses and adverse events. A disease course is a pathological bodily process that produces specific signs or symptoms at a specific location of a patient. An adverse event is a pathological bodily process that occurs after a medical intervention such as a drug or vaccine administration (He et al., 2014). To be a vaccine adverse event, an abnormal medical condition should occur after a vaccination. However, the causal relation is not necessary. Based on the logical, we developed a ontology-based strategy to study AKI adverse event using OHDSI data.

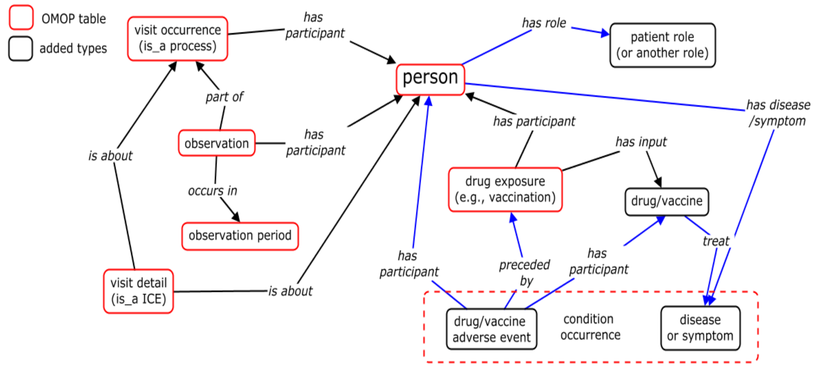

Fig. 1. Ontological representation and differentiation of adverse event and disease course based on OHDSI CDM and datasets.

The terms highlighted in red boxes represent table names in OPMI CDM. OPMI also includes new terms (e.g., patient role and specimen assay) for more logical representation.

To demonstrate the usage of OPMI to study OMOP CDM, we used the data extracted from the IQVIA Pharmetric Plus database data (https://www.iqvia.com), which had already been converted into the OMOP CDM format. In this study, kidney disease data were extracted from the database based on the OPMI data model. Supported by this model, we developed an algorithm to identify the concept IDs that covered the correct conditions of interest. Once identified, we extracted the patients who initially did not have acute kidney injury (AKI), then vaccinated, and diagnosed with AKI afterwards. The SNOMED concept term "Acute renal failure syndrome" and 62 other associated concept terms were used.

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Results: OHDSI data extraction and ontology-based analysis

Our OHDSI cohort study identified 6,148 patients that fulfilled our AKI adverse event selection criteria: no AKI within one month before vaccinations and having AKI within two weeks after vaccinations. Among these patients, 60.5% are male and 39.6% are female patients, and the group aged 60-64 is the highest population with the AKI vaccine adverse event (Fig. 2).

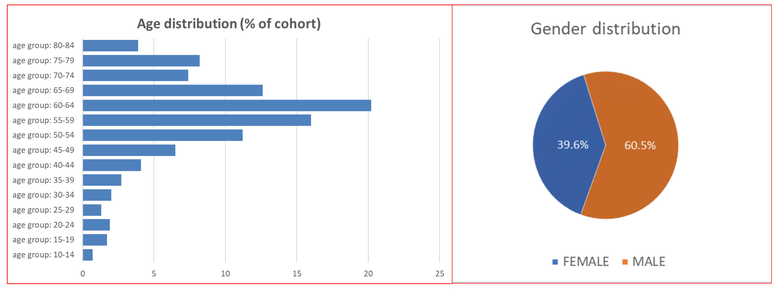
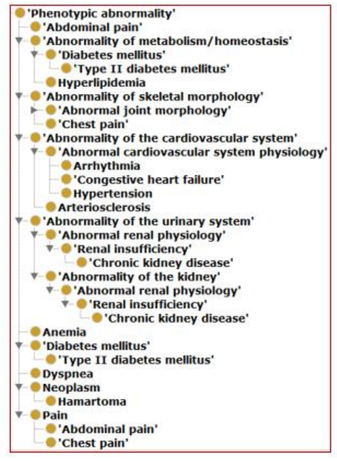
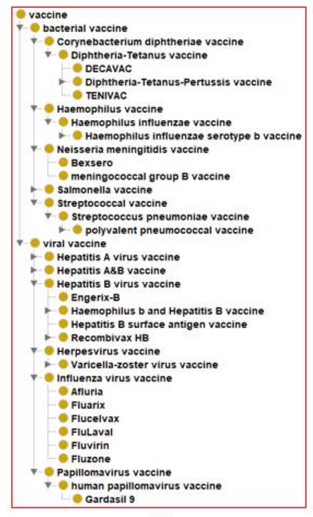


Fig. 2. Demographic distribution of our cohort population of vaccine-associated AKI adverse event. (A) Age distribution. (B) Gender distribution.

Our further study found many abnormal phenotypes, including chronic kidney disease and diabetes, that occurred before vaccinations followed with AKI adverse event (Fig. 3A). Many bacterial and viral vaccines such as Haemophilus influenzae vaccine, hepatitis A and B vaccines and influenza vaccines, were identified.



(A)



(B)

Fig. 3. Identification of conditions and vaccines associated with AKI adverse event using OHDSI data and OPMI ontology modeling. (A) The conditions represented using HPO; (B) Vaccines represented using VO.

For patients with chronic kidney diseases, vaccinations are often suggested to boost their immune responses against future wild type infections. However, these patients might have a chance to have acute kidney injury as vaccine adverse event. Further analysis is deserved to identify the underlying patterns and mechanisms.

Conclusions and discussion

Our study demonstrates that OPMI is able to accurately model and represent the semantic relations among OMOP CMD elements, and the ontology-based strategy provides a systematic and logical way to analyze vaccine adverse events using OHDSI data.

Acknowledgements

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References

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