Derivation of novel phenotypes of outpatient pediatrician prescribing patterns

Joshua C. Herigon, MD, MPH, MBI[1]; Jonathan Hatoun, MD, MPH, MS[1,2]; Louis Vernacchio MD, MSc[1,2]
[1]Boston Children's Hospital & Harvard Medical School; [2]Pediatric Physicians' Organization at Children's Hospital (PPOC)

Boston Children's Hospital

Abstract

Background: Antibiotics are the most commonly prescribed drugs for children with estimates that 30%-50% of outpatient antibiotic prescriptions are inappropriate. Most analyses of outpatient antibiotic prescribing practices do not examine patterns within individual clinicians' prescribing practices. We sought to derive unique phenotypes of outpatient antibiotic prescribing practices using an unsupervised machine learning clustering algorithm.

Methods: We extracted diagnoses and prescribing data on all problem-focused visits with a physician or nurse practitioner between 6/11/2018 – 12/11/2018 for a state-wide association of pediatric practices across Massachusetts. Clinicians with fewer than 100 encounters were excluded. The proportion of encounters resulting in an antibiotic prescription were calculated. Proportions were stratified by diagnoses: otitis media (OM), pharyngitis, pneumonia (PNA), sinusitis, skin & soft tissue infection (SSTI), and urinary tract infection (UTI). We then applied consensus k-means clustering, a form of unsupervised machine learning, across all included clinicians to create clusters (or phenotypes) based on their prescribing rates for these 6 conditions. A scree plot was used to determine the optimal number of clusters.

Results: A total of 431 clinicians at 77 practices with 234,288 problem-focused visits were included. Overall, 42,441 visits (18%) resulted in an antibiotic prescription. Individual clinician prescribing proportions ranged from 5% of visits up to 44%. The optimal number of clusters was determined to be four (designated alpha, beta, gamma, delta). Antibiotic prescribing rates were similar for each phenotype across AOM, pharyngitis, and pneumonia but differed substantially for sinusitis, SSTI, and UTI. The beta phenotype had the highest median rates of prescribing across all conditions while the delta phenotype had the lowest median prescribing rates except for UTI.

Conclusion: Antibiotic prescribing varies by both condition and individual clinician. Clustering algorithms can be used to derive phenotypic antibiotic prescribing practices. Antimicrobial stewardship efforts may have a higher impact if tailored by antibiotic prescribing phenotype.

Background

- Previous studies have examined antibiotic prescribing variability using inter-practice variation and inter-clinician variation within practices
- However, little research exists on intra-clinician antibiotic prescribing (e.g., does a given clinician prescribe at uniform rates across disparate infectious diagnoses like acute otitis media, pneumonia, skin/soft tissue infections, etc.)
- More nuanced understanding of prescribing practices could allow for precisions stewardship interventions targeted at specific clinicians for specific diagnoses
- We sought to derive unique prescriber phenotypes of outpatient antibiotic prescribing using an unsupervised machine learning clustering algorithm

Corresponding Author
Joshua Herigon MD, MPH, MBI
joshua.herigon@childrens.harvard.edu
www.joshherigon.com

Acknowledgements
Joshua Herigon was supported by a National Library of Medicine Biomedical Informatics and Data Science Research Training Grant (T15LM007092)

Methods

Study Design: retrospective cohort study

Setting/Population

- 80+ independently-owned pediatric practices affiliated with Boston Children's Hospital, includes 400+ clinicians taking care of 400,000 children
- Inclusion criteria:
  - Problem-focused visit
  - Encounter between 6/11/2018 – 12/11/2018
  - Age 3 months – 18 years old
  - 77 practices included (those with complete data throughout study period)
- Exclusions:
  - Phone encounters
  - Clinicians with < 100 total encounters

Analysis

- Proportion of encounters resulting in an antibiotic stratified by diagnosis was calculated for each clinician
- *k*-means clustering
  - Unsupervised machine learning algorithm
  - Clusters data based on grouping data together around 'centroids' by reducing the sum of squares within a cluster
  - Iterates over the data allocating each data point to different centroids to find the smallest clusters possible
  - Number of clusters is defined *a priori*
    - 2 – 15 clusters were examined
    - A scree plot was then used to define the optimal number of clusters

Results

Table 1. Patient (left) and clinician (right) characteristics

Age, median years [IQR[a]]	6.8 [9.6]
Sex (%)	
Female	115,342 (49)
Male	120,033 (51)
Race/Ethnicity	
White (Non-Hispanic)	134,484 (57)
Hispanic or Latino	23,766 (10)
Asian	8,083 (3.4)
Black (Non-Hispanic)	6,773 (2.9)
Other/Unknown	62,269 (26)
Insurance type (%)	
Private	161,800 (69)
Public	73,575 (31)
Complex Chronic Condition (%)	24,770 (10.5)

[a]Inter-quartile range

Practices	77
Clinicians per practice, median [IQR]	5 [7]
Clinician age, median [IQR]	49 [18]
Sex (%)	
Female	324 (75)
Male	110 (25)
Clinician type (%)	
MD/DO	333 (77)
NP	96 (22)
PA	5 (1.2)

Fig 1. Proportion of encounters resulting in an antibiotic by diagnosis

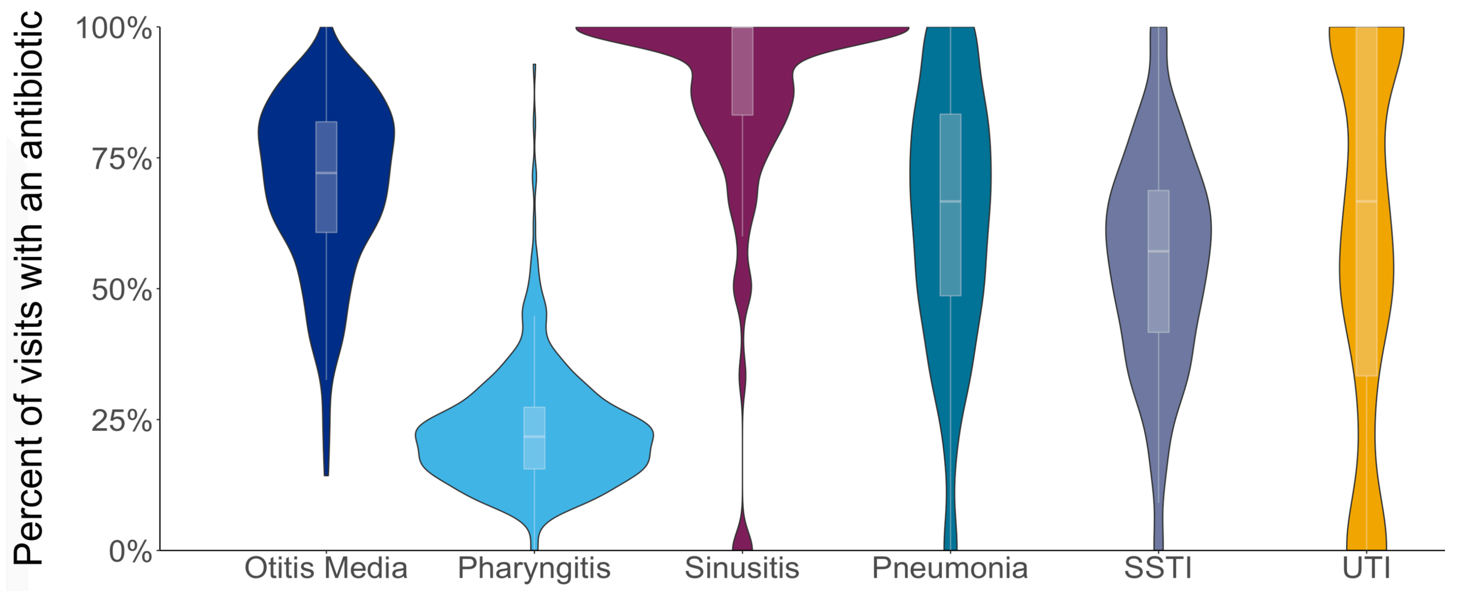
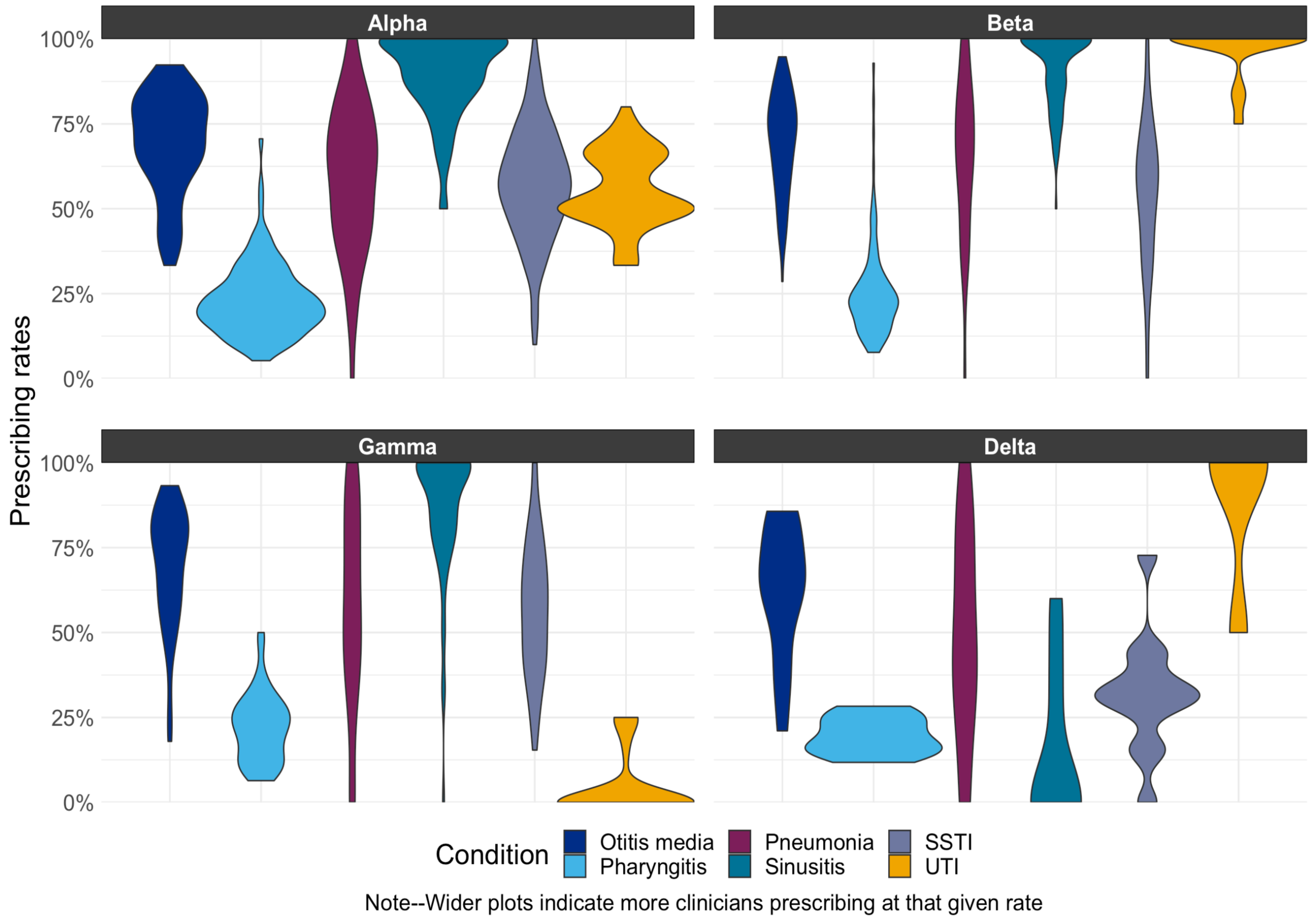


Fig 2. Proportion of encounters resulting in an antibiotic by diagnosis and stratified by the four prescriber phenotypes



Conclusions

Antibiotic prescribing varies by both condition and individual clinician. Clustering algorithms can be used to derive novel antibiotic prescriber phenotypes. Antimicrobial stewardship efforts may have a higher impact if tailored to specific conditions and antibiotic prescriber phenotype.