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"All models are wrong, but some are useful": On the non-bayesian statistical robustness of Hilton's law

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Dear Editor,

We shall discuss the possibility of a deficit in connection to the renowned Hilton's Law endorsed by the esteemed fellow of the Royal College of Surgeons, Dr. John Hilton. Hilton's keen observation and assumption on the innervation patterns of joints remained unchallenged since the 19th century. Almost 150 years after, we propose putting Hilton's Law into a rigor test based on concepts of Non-Bayesian models of statistical inference, predictive analytics, and measures of statistical power and accuracy.

BACK TO THE NINETEENTH CENTURY: HILTON'S LAW

As with most contemporary British surgeons and fellows of the Royal Colleges of Surgeons in the nineteenth century, John Hilton based his keen observations upon extensive anatomical knowledge and practice guided by clinical experiences (Hilton, 2009). The famous Hilton's Law, established over one and a half century ago in a series of medical lectures instructed from 1860 to 1862, dictates that the nerve supplying a muscle extending directly across and acting upon a given joint will not only provide the muscular tissue with neural innervation, but will also innervate the joint and the skin overlying that muscle (Hilton, 2009; Hébert-Blouin et al., 2014). It seems that Hilton's observation of this constitutional law of nature withstood the test of time. However, we need to know how far accurate was John Hilton's assumption. We aim to test the hypothesis behind Hilton's Law with regards to its generalizability and statistical accuracy from a data-science perspective. The primary objective is to run a systematic analysis of the bodily articulations (joints) and evaluate the validity of the established Hilton's Principle, thereby challenging, historically and scientifically, the esteemed John Hilton.

HILTON'S LAW: IS IT "BULLETPROOF"?

The chronological hierarchy of the study and the related methodology throughout the research will pragmatically: (I) Conduct a systematic review of the databases of literature in connection with the primary objective, including relevant publications on the historical as well as the scientific aspects of

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Hilton's Law; (II) Optimize the systematic review of literature by deploying automated, non-human mediated, retrieval of publications and the corresponding indexing data in real-time from the gold-standard established databases of the published literature, including the Cochrane Library [the Cochrane Database of Systematic Reviews | the Cochrane Collaboration], PubMed [the United States National Library of Medicine], and Embase [Elsevier], as well as the unpublished "grey" literature (Al-Imam et al., 2019; Al-Imam, 2019a, b). This step will require the implementation of high-level programming languages, including MatLab, Octave, R, and Python, in addition to spreadsheet templates and statistical packages for social sciences including SPSS [IBM-SPSS version 25] and Microsoft Excel [Microsoft Office Excel 2016 with the Analysis ToolPak add-in]. (III) Create analytics based on the systematic review of literature in an attempt to discover a deficit that may portray some degree of statistical imprecision of John Hilton's law. (IV) Compare the results from the systematic review of the literature with collateral data from resources of big data, including Google Trends and Google Analytics. The aim is to evaluate the popularity of Hilton's Law among scholars over the surface web and to assess the geographic mapping of relevant data signals at a global scale (Figure 1), while establishing a time-series analytics for this purpose. (V) Following the review of the literature, we shall create a second database for the neural-muscular innervation patterns of the joints of the body. We shall also test a plethora of joints other than the classical mobile synovial joints, as well as assess how branchiomeric muscles may deviate from the Law of Hilton. A pairwise comparison will be also feasible for cranial versus peripheral nerves. (VI) Eventually, we will tabulate the reality of the status of innervation [based on validated and replicated macro—microscopic peer-reviewed research] versus the prediction [based on Hilton's Law], upon which we can operate an array of data analytics to extrapolate an inference with a projected confidence interval of 95% [type-1, α-error of 0.05] and a statistical power of 80% [type-2, β-error of 0.02]. (VII) The statistical inference will be heavily-based on two-groups of observation versus prediction [i.e., between-subjects study design], and pairwise statistical contrast of peripheral versus cranial nerves in addition to branchiomeric versus non-branchiomeric muscles, as well as the upper extremity versus the lower extremity, to evaluate the statistical "fidelity" of the subsistent 18th century's law. (VIII) In the case of non-violation of assumptions of parametric tests, we anticipate running an array of non-Bayesian inferential analytics (Gelman, 2008; Al-Imam and Khalisy, 2019). Statistical testing will initiate with the determination of the skewness-kurtosis and the status of normality of distribution, via the Shapiro-Wilk or Kolmogorov-Smirnov test, and eventually concluding with Pearson's product-moment correlation, Independent Student's t-test, and Fisher's One-Factorial ANO-

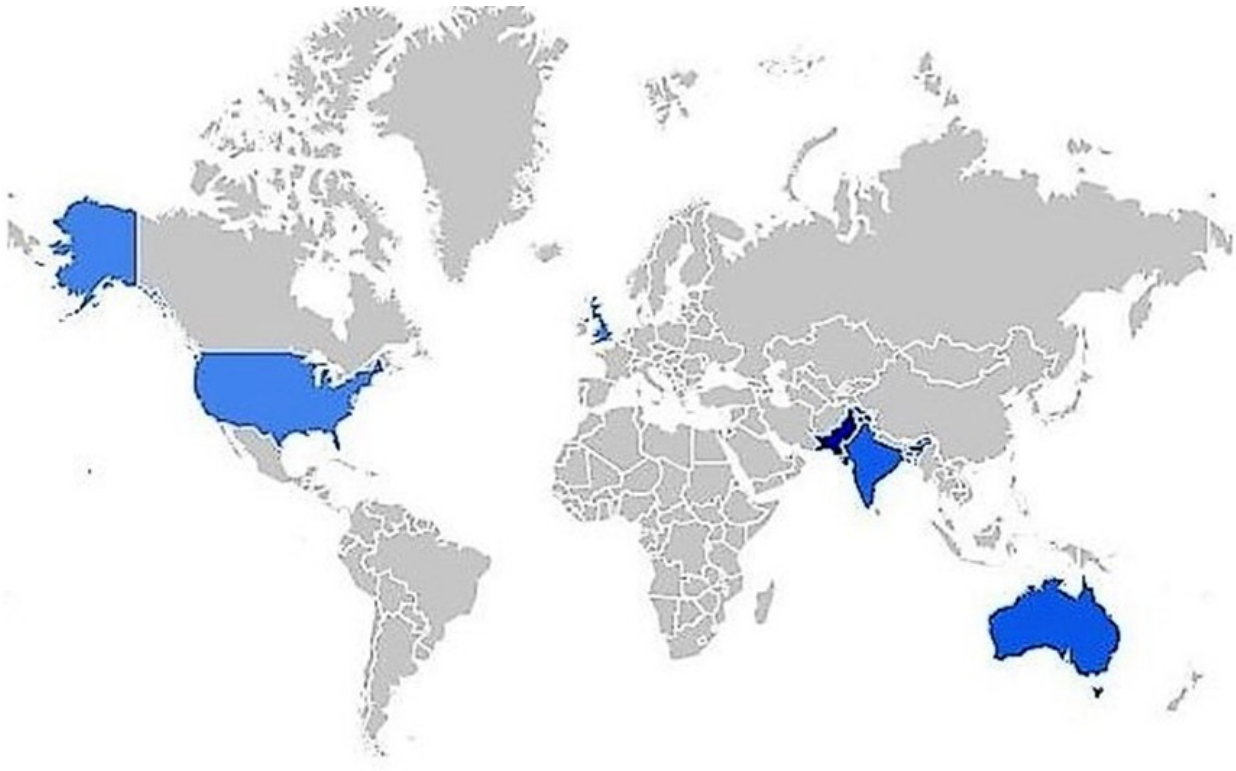

Fig 1. Keywords-Based Geographic Mapping.

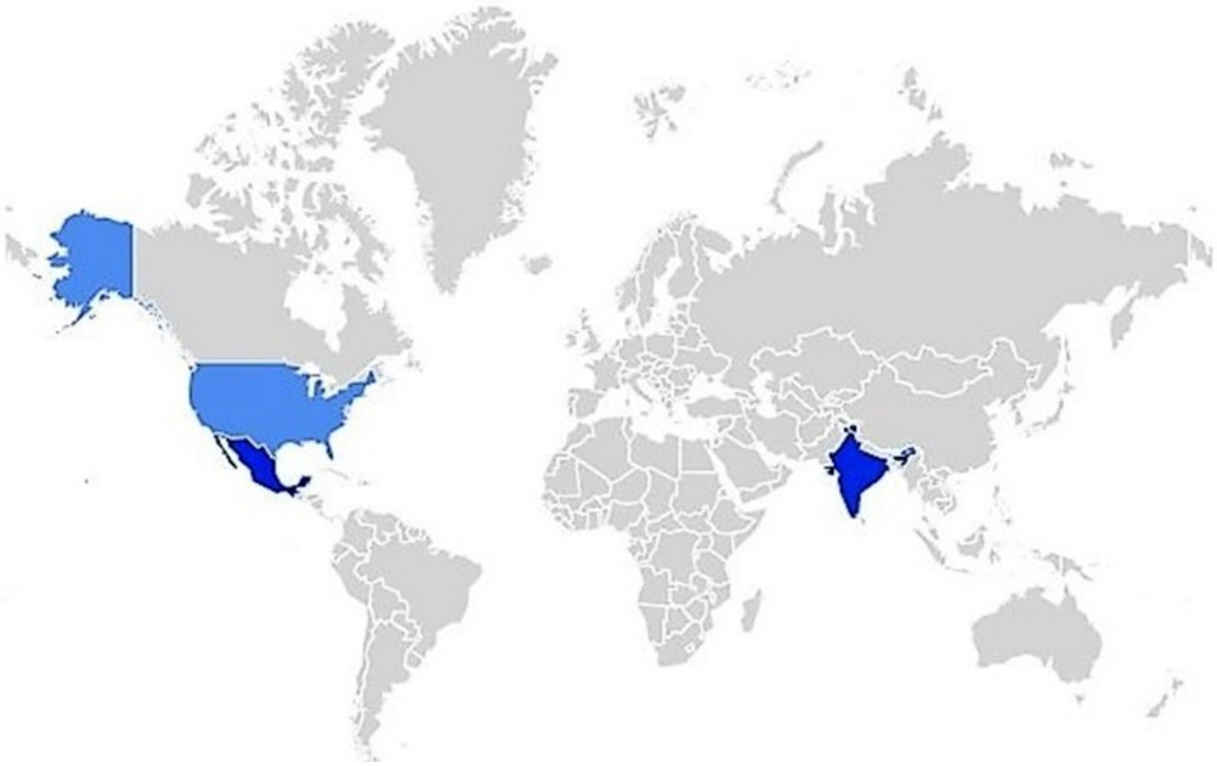

Fig 1. Keywords-Based Geographic Mapping.

† Retrospective Mapping via Google Trends [2004-current] [Time-stamp: September 1st, 2019].

†† Hilton's Law [Topic] (upper map) and John Hilton [British Surgeon] (lower map).

VA (Razali and Wah, 2011). (IX) In case of violation of the assumptions of the parametric tests [i.e., the normality of distribution, the existence of statistical outliers, homoscedasticity, and other test -specific assumptions], we shall implement data transformers (Takeda et al., 1982; O´Hara and Kotze, 2010). To tackle datasets that are not normally distributed, an innovative method will be deployed, based on sinusoidal data transformation to maneuver towards an approximation of normality in distribution (Al-Imam, 2019c). This step can also be of value for future research in connection with data science by reducing the computational cost-time function via enhancing the mathematical basis required for processing elaborate matrices of big data. (X) The analytics will build up towards calculating the sensitivity and specificity, predictive values [positive and negative], the magnitude of error, and statistical noise, in addition to conducting a receiver operating characteristic (ROC curve analysis) for an ultimate assessment of the accuracy of this archetypal law of innervation espoused by the far-famed 19th century surgeon, Dr John Hilton (Cohen, 1992; Kraemer and Blasey, 2015; Akobeng, 2016; Agapiou et al., 2017).

DISSEMINATION OF THE RESULTS

We shall disseminate our knowledge by introducing the concept and research output of the study via: 1) continuing medical and professional education Lectures; 2) publishing the results of the study, with an aim for two papers, including an original manuscript and an editorial paper, in high-impact journals of anatomical and natural sciences; 3) presenting conclusive data in international conferences and public events; 4) formating the research as a book publication dedicated to endowed anatomists, neurologists, and surgeons as well as biologists and naturalists.

LEVEL-OF-THE-EVIDENCE

Level-5 [Expert opinions based on non-systematic reviews of result or mechanistic studies].

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