

INFERRING SKIN-BRAIN-SKIN CONNECTIONS FROM INFODEMIOLOGY DATA USING DYNAMIC BAYESIAN NETWORKS

M.SCUTARI⁽¹⁾, D.KEROB⁽²⁾, S.SALAH⁽²⁾

⁽¹⁾Istituto Dalle Molle di Studi sull'Intelligenza Artificiale (IDSIA), Lugano, Switzerland. – ⁽²⁾La Roche-Posay Dermatological Laboratories, Levallois-Perret, France

INTRODUCTION

The relationship between skin diseases and mental illnesses has been extensively studied in the literature using cross-sectional epidemiological data. Typically, such data can only measure association (rather than causation) and include only a subset of the diseases we may be interested in. In this work, we complement the evidence from such analyses by learning a dynamic Bayesian network of 13 conditions from the Google search trends dataset. The resulting network model can represent both cyclic and acyclic causal relationships, is easy to interpret and accounts for the spatio-temporal trends in the data in a probabilistically rigorous way.

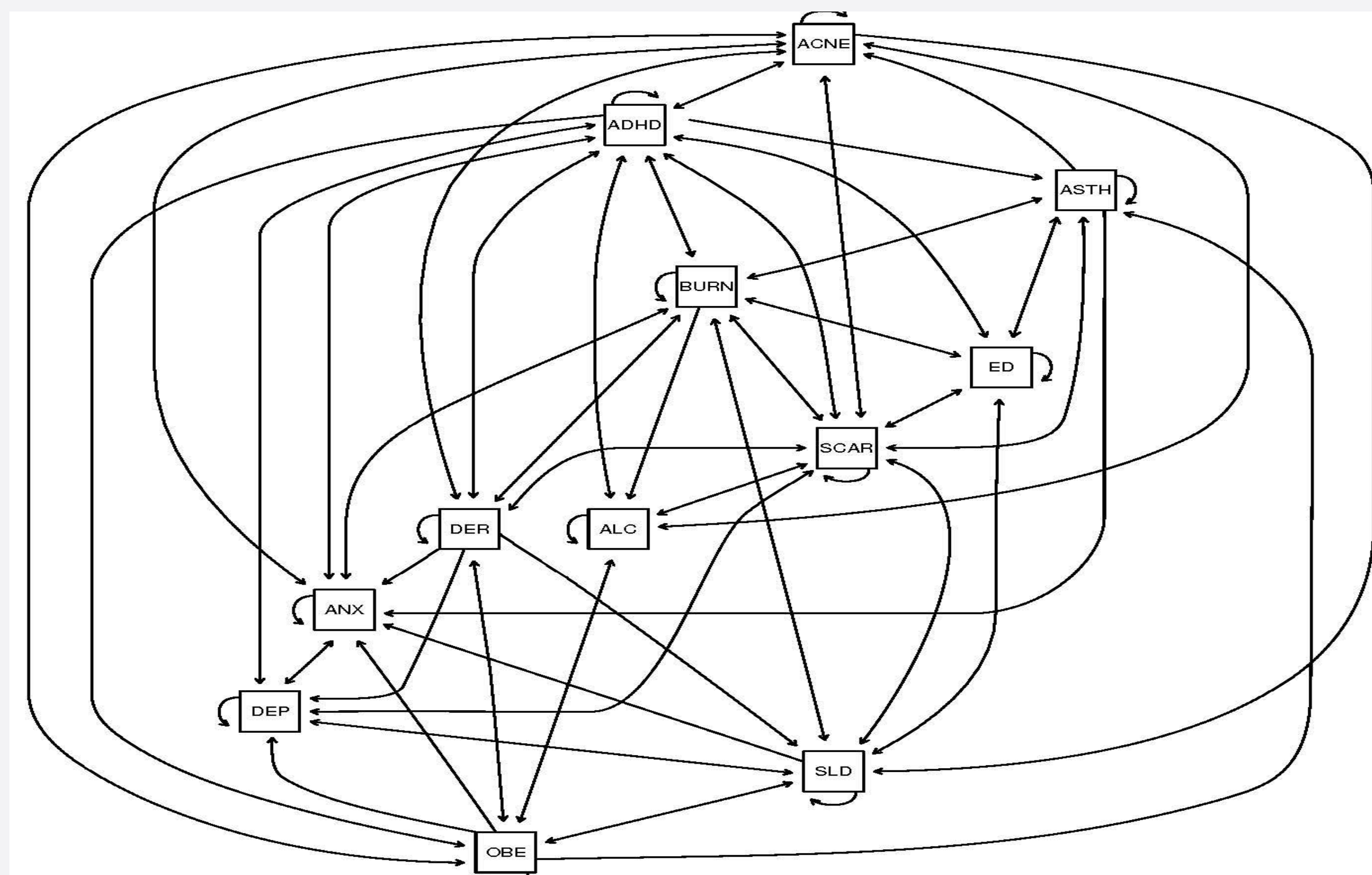
MATERIAL & METHODS

In this study we used the Google COVID-19 Public Dataset, an analysis ready large longitudinal search dataset, to model the interplay between skin diseases and mental illnesses using dynamic Bayesian networks (dynamic BNs). We focus on the following 13 conditions: obesity ("OBE"), acne ("ACNE"), alcoholism ("ALC"), anxiety ("ANX"), asthma ("ASTH"), attention deficit hyperactivity disorder ("ADHD"), burn ("BURN"), depression ("DEP"), dermatitis ("DER"), erectile dysfunction ("ED"), sleep disorder ("SLD"), itch ("ITCH") and scar ("SCAR"). The dataset provides the relative frequency in web search queries of the relevant search terms in each county of each US state over the 2020-03-02 and 2022-01-24 period (100 weeks). The overall number of observations for each condition given by 2879 counties over 50 states and 100 weeks is 287900. Both uni-directional effects and feedback loops were learned in an unsupervised manner. In order to reduce false positives (which in this context implies including spurious arcs in the dynamic BN), we structured the dynamic BN to account for the temporal and spatial dependence structure of the data and we integrated model averaging via bootstrap resampling in the learning process. Furthermore, we tuned the learning process by penalizing the inclusion of arcs in the dynamic BN to find the optimal balance between predictive accuracy and the need to obtain a sparse network

RESULTS

Results (Figure 1) confirm the strong and cyclic skin-skin and brain-brain relationships. We observed strong cyclic relationships, between skin and brain search popularities. For acne, we observed a direct and cyclic relationship with anxiety and an indirect relationship with depression through sleep disorders. For dermatitis, we observed an indirect link with anxiety through an acyclic impact on sleep disorder and an indirect link with depression through attention deficit hyperactivity disorder. Furthermore, the network highlighted the strong weight of sleep disorder on health characterized by the high number of direct connections with diseases in the network. The network confirm also the strong link between mental diseases with frequent cyclic relationships between them.

Figure 1: The dynamic Bayesian network linking skin and brain conditions learned from the Google COVID-19 Public Dataset



DISCUSSION

Even though the modeled causations are infodemiologic and not clinical, the results confirmed the interplay between skin and mental diseases. Several skin-to-skin, brain-to-brain, skin-to-brain and brain-to-skin relationships are highlighted in the model. It would be interesting to see well-known clinical relationships between skin and mental diseases reproduced on these data and put into a larger context with deeper explanations. The large number of feedback loops supports the existence of vicious circles in which diseases exacerbate each other until treated appropriately. The results are unable to elucidate the starting point of these circles but emphasize the need for a more holistic disease management for both dermatologists and psychiatrists. Dermatologists should take into account the mental health of their patients just as psychiatrists should take into account the skin problems of their own patients.

References:

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