LEARNING NETWORK STRUCTURE FOR POTENTIAL DETERMINANTS OF FOOD SAFETY PRACTICES IN CAMBODIA'S INFORMAL VEGETABLE MARKETS

***Vrinda Ambike*[1]**, *Sabrina Mosimann*[2], *Keorimy Ouk*[3], *Paul D. Ebner*[2] *and Nora M. Bello*[1]

[1]The Ohio State University, OH USA; [2]Purdue University, IN USA; [3]Royal University of Agriculture, Phnom Penh, Cambodia

INTRODUCTION

- Informal vegetable markets play an important role in the economy and health of Cambodians.

- Food safety measures not adequately enforced in these markets predispose consumers to several food-borne diseases that degrade quality of life.[1]
- Implementation of the food safety practices can be facilitated by an enhanced understanding of human behavior.
- The Capability, Opportunity, Motivation-Behavior (COM-B) model[2] (Figure 1) is a theoretical framework used to study determinants of human behavior and to develop context-specific interventions that promote behavioral change. COM-B recognizes behavior as determined by a combination of capabilities (mental and physical ability to perform a behavior), opportunities (favorable set of circumstances external to the individual that prompt a behavior), and motivations ("mental processes that energize and direct behaviors")[3].
- The Theoretical Domains Framework (TDF)[4,5] further deconstructs COM-B constructs into twelve measurable domains that enabled development of a quantitative questionnaire[3].
- We explore the use of Inductive Causation (IC)[6] algorithm on empirical questionnaire data to substantiate the COM-B theoretical behavior model.

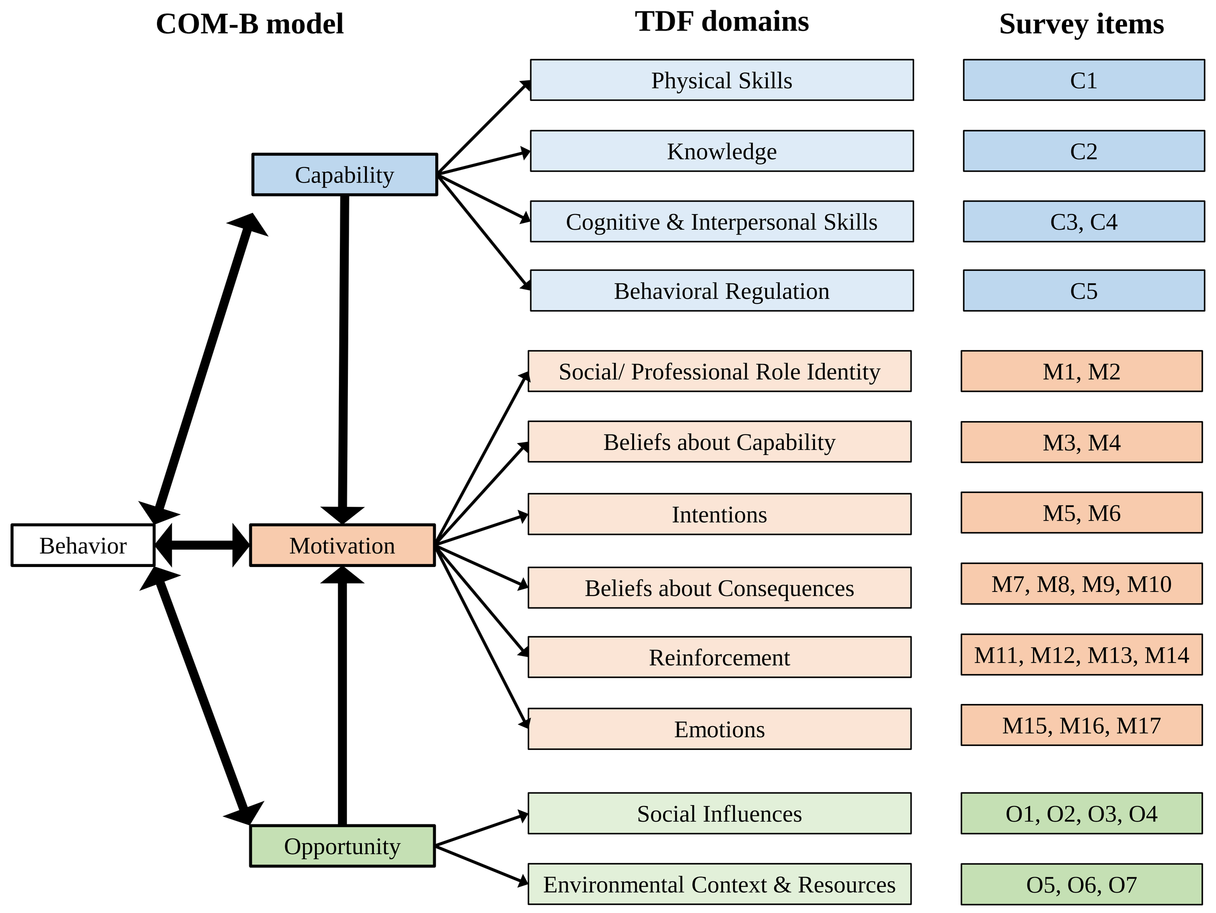


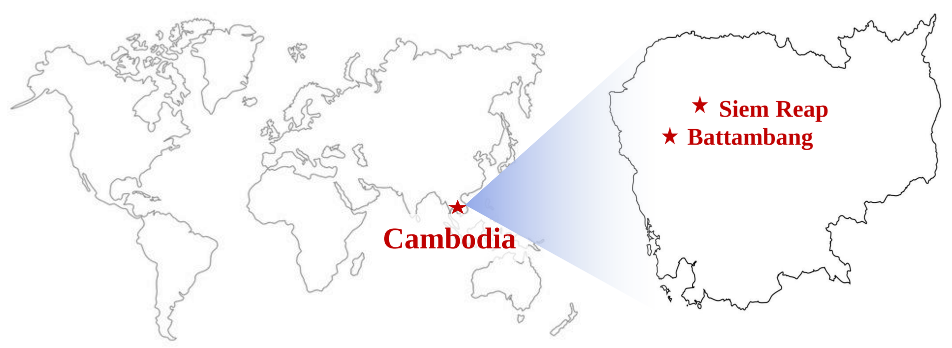
Figure 1: COM-B Model of Behavior, TDF domains and 29 survey items

OBJECTIVE

To search for potential causal network structures among the behavioral determinants specific to food safety practices in informal vegetable markets in Cambodia.

METHODS

- Data collected from 169 vegetable farmers, vendors and distributors belonging to Battambang and Siem Reap provinces in Cambodia.



- Survey developed following COM-B and TDF frameworks: 29 items recorded on a 1-to-7 (agree/disagree) Likert scale.[3]
- Selected 18 survey items representing COM-B constructs of Capability (3 items), Opportunity (4 items) and Motivation (11 items). Most (10 out of 12) TDF domains represented.

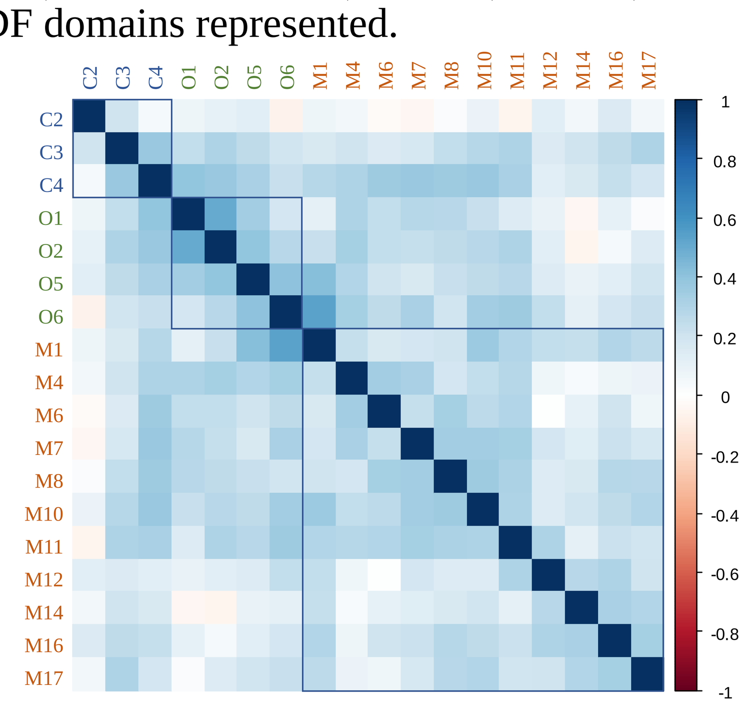


Figure 2: Spearman correlations between selected 18 survey items

- Given the ordinal nature of the data, Spearman rank-order correlation coefficients (marginal and partial) were computed for each pair of conditional items, given all possible conditioning sets consisting of all combinations of remaining items.
- Total number of operations is proportional to number of conditioning sets.

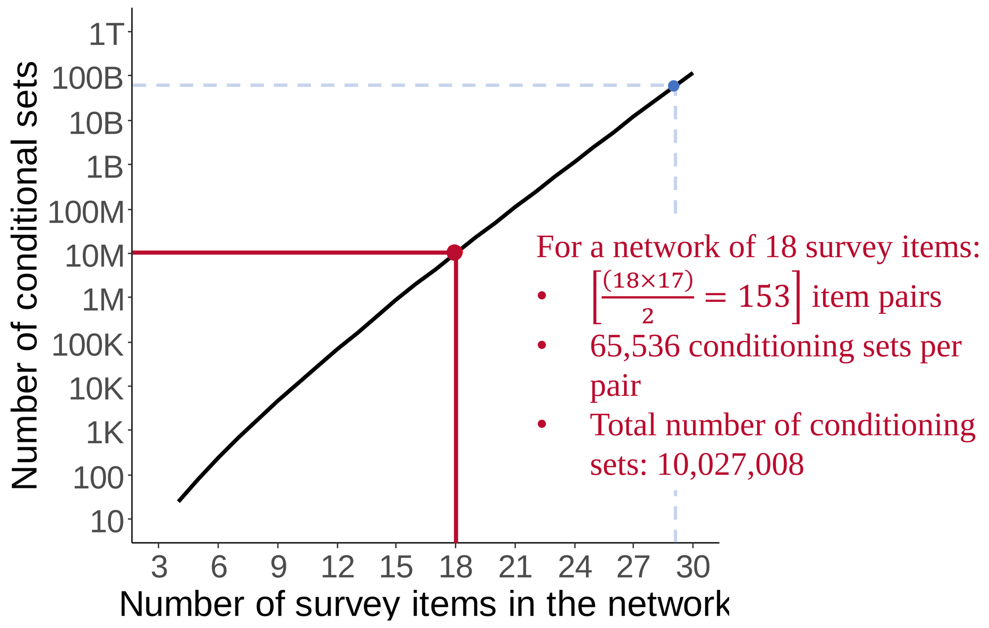


Figure 3: Exponential increase in the number of conditional sets as a function of number of survey items in the network

Partial correlations[7]

- Covariance matrix **S** for survey items X,Y and conditioning set Q.
- Concentration matrix **C** given by $\mathbf{S}^{-1}$.
- Partial correlations for a pair (X,Y) of survey items conditional on Q set of other survey items given by $r_{X,Y|Q} = \frac{-c_{XY}}{\sqrt{c_{XX}c_{YY}}}$.

Inductive Causation algorithm[6]

- Series of (t-test based) statistical decisions implemented on Spearman correlations to search the space of network structures and learn plausible networks consistent with correlation patterns in data.
- Steps involved in IC algorithm:

1. For each pair of *j* and *j'* survey items, if all partial correlations differ from zero, connect items by an undirected edge (e.g: *j* — *j'*), to yield an undirected dependency graph (UDG or skeleton).
2. From skeleton in (1), consider every pair of disconnected items that share a common adjacent item (e.g: *j* and *j"* in *j* — *j'* — *j"*) and evaluate all partial correlations between the pair that include the common adjacent item in the conditioning set. If all such partial correlations differ from zero, direct the edges towards the common adjacent trait to define an unshielded collider and yield a partially oriented graph.
3. Lastly, without creating new colliders or cycles, orient as many edges as possible to obtain a directed acyclic graph (DAG).

- Threshold levels of significance implemented on Spearman correlations: 0.05, 0.10, 0.15, 0.20.
- Implementation: R package "ppcor"

RESULTS

Undirected Dependency graphs

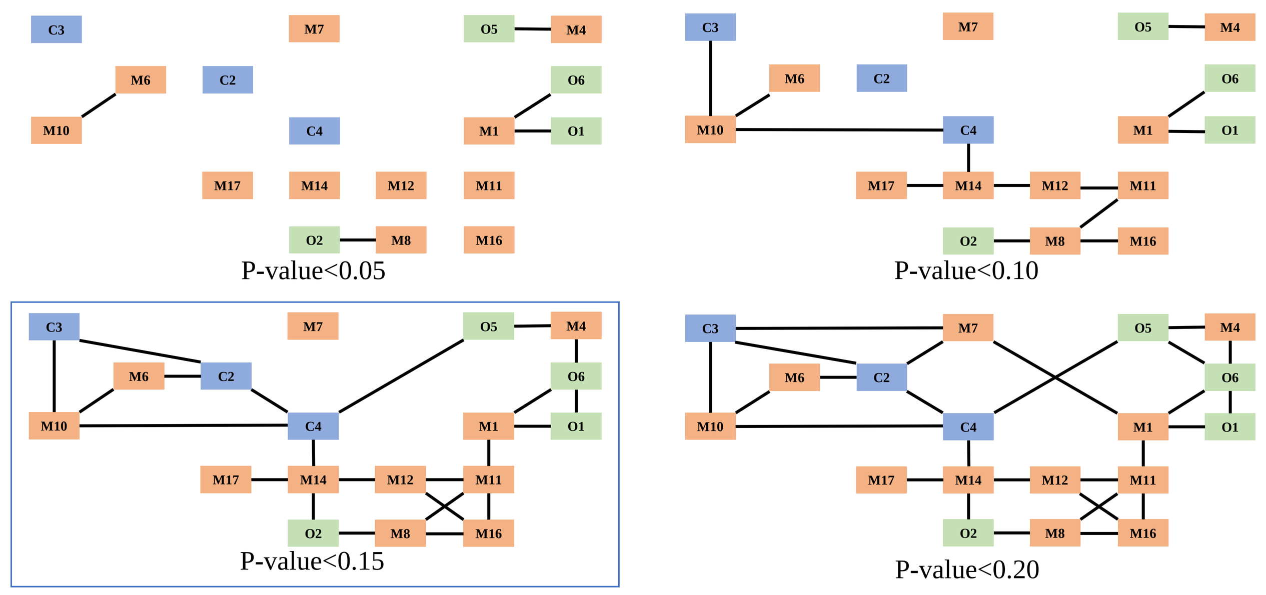


Figure 4: Undirected Dependency Graphs

- IC Step 1: the number of edges in the learnt network increased with the significance threshold.
- Significance threshold of 0.15 selected for further evaluation to balance the probability of missing true connections (Type II error) and the probability of including false connections (Type I error).

Partially Directed Acyclic Graph

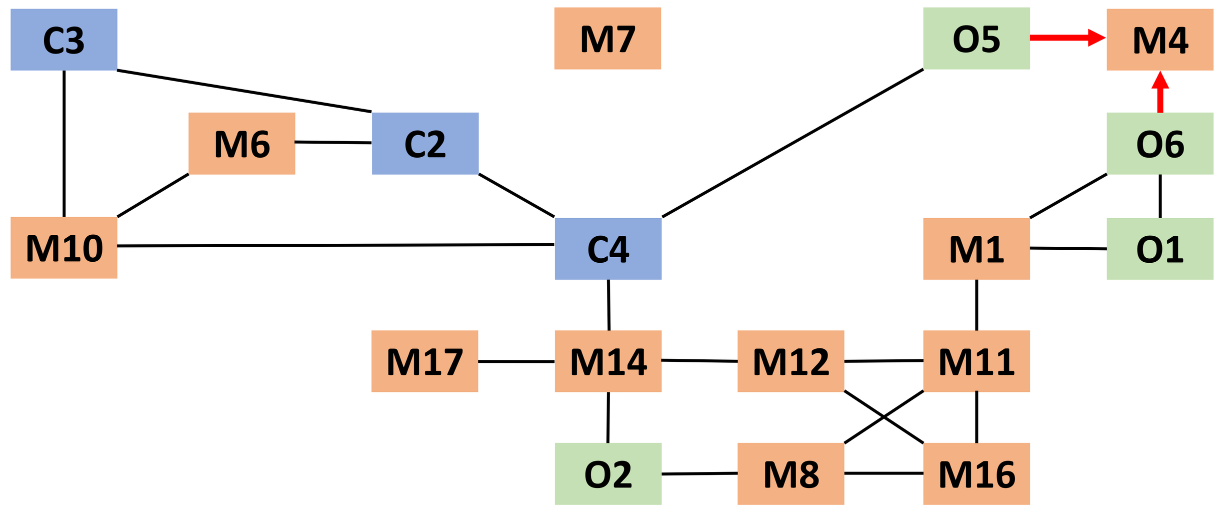


Figure 5: Partially directed graph (P value < 0.15)

- IC Step 2: Only one unshielded collider detected, yielding a partially oriented graph. Directed edges learnt from survey items connect the COM-B Opportunity construct to the COM-B Motivation construct (O5 → M4 ← O6).

CONCLUSION

- Data-informed network structures learned from survey of behavioral determinants of food safety practices in Cambodian informal vegetable markets were consistent with expectations from the COM-B theoretical framework for behavioral change. Survey items corresponding to the Capability and Opportunity constructs were mostly connected to survey items corresponding to the Motivation construct through direct links (i.e. edges).
- However, survey data informed directionality of a limited number of network edges. Additional empirical work is warranted to further refine substantiation of the COM-B model for behavioral change.
- Our application illustrates the use of Spearman rank-order correlations to extend IC-based searches for network structure to ordinal data.

REFERENCES

[1]Thompson, L., Vipham, J., Hok, L. & Ebner, P., 2021. Towards improving food safety in Cambodia: Current status and emerging opportunities. *Global Food Security*, 31, p.100572.

[2]Michie, S., van Stralen, M.M. & West, R. (2011) The behaviour change wheel: A new method for characterizing and designing behaviour change interventions. *Implementation Science, 6,* 42.

[3]Mosimann, S., Ouk, K., Bello, N.M., Chhoeun, M., Vipham, J.L., Hok, L. & Ebner, P., 2023. Describing capability, opportunity, and motivation for food safety practices among actors in the Cambodian informal vegetable market. *Frontiers in Sustainable Food Systems*, *7*, p.108.

[4]Cane, J., O'Connor, D., & Michie, S. (2012). Validation of the theoretical domains framework for use in behaviour change and implementation research. *Implementation Science*, *7*, 37.

[5]Michie, S., Atkins, L., & West, R. (2014). *The behavior change wheel: A guide to designing interventions*. Silverback Publishing.

[6]Verma, T., & J. Pearl. 1991. Equivalence and synthesis of causal models Proceedings of the Sixth Annual Conference on Uncertainty in Artificial Intelligence. Elsevier Science Inc, New York. p. 255–270.

[7]Shipley, B. 2016. Cause and correlation in biology: a user's guide to path analysis, structural equations and causal inference. 2nd ed. Cambridge University Press, New York.

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PURDUE UNIVERSITY

Royal University of Agriculture

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COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES