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## "Hidden" Social Networks in Behavior Change Interventions

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## **“Hidden” social networks in behavior change interventions**

**Abstract**

Many behavior change interventions do not account for the interaction among participants (i.e. social networks) and how such interactions may affect intervention outcome. We investigated if such networks were evident in a physical activity behavior change intervention. Results showed evidence of unobserved social networks in the intervention and illustrated how the network evolved over short time periods and impacted on behavior. These so-called “hidden” (or unobserved) social networks have typically been overlooked, unobserved and subsequently under-utilized in behavior change interventions.

## Introduction

Complex behavior change interventions have unintentional and unobserved consequences and effects which must be captured to help us fully understand mechanisms of behavior change.<sup>1</sup> For example, many interventions do not account for the interaction among participants (i.e. social networks) and how such interactions may affect intervention outcome.<sup>2</sup>

Berkman<sup>3</sup> illustrates how social networks impact health through social interactions at the micro level impacting behavior at the meso and macro levels, and previous research has helped us understand the impact of social networks on a range of health behaviors.<sup>4-13</sup>

We argue that so-called “hidden” (or unobserved) social networks are inherent in behavior change interventions, particularly in cluster trials, and hypothesize that such networks are impacting on the outcome of behavior change interventions. The objectives of this study were:

1. To investigate if social networks are evident in a physical activity behavior change intervention;
2. If evident, to investigate the characteristics and evolution of the network structure over time.

## Methods

Objective social network and physical activity data were collected concurrently over a 12-week period, from a quasi-experimental trial of a financial incentive intervention.<sup>14</sup> Sensors (Near Field Communication readers) were placed along footpaths and gym in the workplace environment. Employees scanned a card (containing a Radio Frequency Identification (RFID) tag) at sensors when undertaking physical activity, such as walking, which created a timestamp (date, time (in seconds) and location) logging their activity.

The timestamp data facilitated the identification of participant’s social networks. Criteria for inferring participants social networks were based on timestamps: (1) on the same day; (2) at the same sensor (at three or more co-occurrences); (3) within 30 seconds (signifying co-occurrences of physical activity behavior and to enable social interactions of more than two people to be captured) (see S1).<sup>15, 16</sup> Minutes of physical activity were calculated by aggregating the minutes between the timestamp data at each scanned sensor.

Network density (proportion of ties in the network), degree centrality (number of ties a node has), triadic census (structure involving three people), total number of social ties (number of co-occurrences of card swipes between at least two participants), and Jaccard Index, a measure of network stability (proportion of stable ties to ties that exist at each time point) were calculated to describe the network structure<sup>17</sup> using UCINET 6<sup>18</sup> and Netdraw.<sup>19</sup>

## Results

Of the 406 participants, 225 engaged in physical activity involving social interactions with at least one other participant (as opposed to those doing physical activity alone or not at all), 5,578 social interactions were inferred over the 12-week intervention with 282 distinct pairings of participants, demonstrating clear evidence of “hidden” social networks within the intervention.

The network graph (Figure 1) illustrates that certain participants formed clear physical activity clusters including cliques of dyadic (19 groups of two people) and triadic structure (nine groups of three people). On average, participants engaged in physical activity with 1.4 (SD 1.8) others (mean degree centrality).

Figure 2 demonstrates the evolution of the social network structure over time. Dyadic and triadic structures are evident at each timepoint illustrating a sustained pattern of participants walking with the same participants. The Jaccard Index showed an increase in stability from 8-11% in week 1-2 to 36-45% in the last 4-weeks of the intervention, suggesting that walking ‘buddies’, once established, remain stable. Results suggested that those engaged in physical activity with others maintain higher activity levels (i.e. 150 mins/week) throughout the intervention, reflected by the larger node size.

## Discussion

Results provide evidence of “hidden” social networks in a complex behavior change intervention and illustrated how the network evolves over short time periods and impact on behavior. Findings demonstrate that those who exercised in pairs or a group maintained higher levels of physical activity than those who did not. Therefore, harnessing and utilizing such networks could help promote and maintain behavior change. This may involve changing the structure or functioning of existing networks, or purposeful development of new social networks. Further, analyses of interventions that take explicit account of previously unobserved “hidden” social networks might better uncover mediators and pathways of initiation and maintenance of behavior change.

Social networks have been identified as an important modifiable mediator of physical activity behavior change,<sup>20</sup> however, we know very little about how to utilize and “exploit” such networks in behavior change interventions networks.<sup>21</sup> To our knowledge, this is the first study to provide explicit evidence of social networks inherent in behavior change interventions. We argue that these so-called “hidden” social networks have typically been overlooked, unobserved and subsequently under-utilized in behavior change interventions. However, the analyses were limited to the influence of those who were enrolled in the physical activity intervention, and we did not consider attempting to model the broader social networks that exist outside of the workplace.

The collection of such data is relatively straightforward and could (and should) be incorporated into future behavior change interventions for a range of behaviors including physical activity, diet, alcohol and smoking. Further, emerging technologies and social media enables unobserved social interactions in behavior change interventions to (1) be objectively measured; (2) capture social interactions directly related to the health behavior under investigation; (3) be measured longitudinally; and, (4) be monitored, manipulated (if appropriate) and analyzed in real-time, and help us better understand the impact of inherent social networks within behavior change interventions. Whether such networks could be harnessed to support a successful public health intervention would depend on a range of practical and theoretical issues that have yet to be studied.<sup>22-24</sup> For example, what psycho-social and behaviour change theories might plausibly underpin the intervention design, how can social networks be optimally designed to generate, accelerate and maintain behaviour change.

**About the Authors:**

Ruth F. Hunter, Ph.D, UKCRC Centre of Excellence for Public Health (NI)/Centre for Public Health, Queen's University Belfast, Institute of Clinical Sciences B, Royal Victoria Hospital, Grosvenor Road, Belfast, BT12 6BJ, Northern Ireland, UK,

Helen McAneney, Ph.D, UKCRC Centre of Excellence for Public Health (NI)/ Institute of Child Care Research, School of Sociology, Social Policy and Social Work/MRC All-Ireland Hub for Trials Methodology Research, Queen's University Belfast, Northern Ireland, UK,

Michael Davis, Ph.D, Centre for Secure Information Technologies (CSIT), Queen's University Belfast, Northern Ireland Science Park, Queen's Road, Queen's Island, Belfast, BT3 9DT, Northern Ireland, UK,

Mark A. Tully, Ph.D, UKCRC Centre of Excellence for Public Health/Centre for Public Health, Queen's University Belfast, Institute of Clinical Sciences B, Royal Victoria Hospital, Grosvenor Road, Belfast, BT12 6BJ, Northern Ireland, UK,

Thomas W. Valente, Ph.D, Institute for Prevention Research, School of Preventive Medicine, Keck School of Medicine, University of Southern California, Los Angeles, California, USA,

Frank Kee, MD, UKCRC Centre of Excellence for Public Health/Centre for Public Health, Queen's University Belfast, Institute of Clinical Sciences B, Royal Victoria Hospital, Grosvenor Road, Belfast, BT12 6BJ, Northern Ireland, UK.

**Corresponding Author Contact Information:**

Dr Ruth Hunter, Centre for Public Health/UKCRC Centre of Excellence for Public Health (NI), Queen's University Belfast, Room 02.015, Institute of Clinical Science B, Royal Victoria Hospital, Grosvenor Road, Belfast, Northern Ireland, United Kingdom, BT12 6BJ; E-mail: [ruth.hunter@qub.ac.uk](mailto:ruth.hunter@qub.ac.uk); Tel: +44 (0) 28 90632947

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**Contributor Statement:**

RH conceived the idea for the study. RH, MD, FK contributed to the study design. RH collected the data. RH, MD, HMCA and TV analysed and interpreted the data. RH drafted the manuscript. All authors read and approved the final manuscript.

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### **Human Participant Protection:**

The study was approved by the Research Ethics Committee of the School of Medicine, Dentistry and Biomedical Sciences, Queen's University Belfast, Northern Ireland. All participants provided informed consent prior to participation.

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**Figure Titles**

**Figure 1:** Network graph showing the derived social networks aggregated over the 12-week intervention period and their relation to achieved level of within trial physical activity.

**Figure 2:** Snapshots of network graphs illustrating the evolving dynamic nature of social networks occurring at week 1, 6 and 12 of the intervention and relation to achieved level of within trial physical activity.

**Supplementary Material:**

Figure S1: Demonstration of collection of “hidden” social networks data.