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A Longitudinal Exploration of Trust in Participatory Health Research – A Network Approach

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ABSTRACT

Background: The value of a participatory approach to the generation of evidence for health and social services from a moral, methodological and policy level continues to develop globally. Trust is a crucial mechanism in the participatory health research (PHR) process and is strongly influenced by its context. However, gaps remain in conceptualising and operationalising trust over time in PHR partnerships.

Objective: This study seeks to address such gaps, exploring the evolution of trust multidimensionally across two time points.

Setting and Participants: Participants from a PHR project called the Public and Patient Involvement Ignite Network in Ireland (n=57 (T1); n=56 (T2)) were invited to complete a network survey at two timepoints. The project had local and national partners.

Network Measures: We calculated several core social network measures at both timepoints characterising differences between the dimensions of trust over time and between local and national partners.

Results: We found subtle changes across most network measures over time and observed a slight decrease in the number of connections for each trust dimension across the network, but a slight increase for connections that were persistently nominated in both timepoints. We noted that some networks were more similar (i.e., vulnerability and integrity) and strikingly different (integrity and shared values, visions, and goals) to each other with a higher number of incoming connections for national compared to local partners.

Conclusion: Our findings serve to 1) provide empirical support for using SNA to operationalise trust comprehensively and multidimensionally over time in a participatory partnership, 2) offer nuanced insights into the trust development process in the PPI Ignite Network over time; and 3) enhance our understanding of trust in the community-based participatory research model.

Strengths and Limitations of this Study:

- This study provides longitudinal empirical support for using tools and techniques from network science to clarify important conceptual and operational complexities of trust in participatory health research partnerships. In doing so, we help address critical ambiguities that hinder the application and evaluation of participatory health research in health promotion.

- Our approach to measuring trust in participatory partnerships embraces its multidimensional nature, allowing us to see how trust unfolds, across all its dimensions, over time.
- By exploring trust in this way, we embraced the partnership environment, which plays an important role in trust and partnership synergy and sustainability.
- This case study used a small network with two time points over a year. Considering trust takes time to develop, it is possible that surveying trust at only two time points over a year is restrictive.
- As trust is inherently contextual, its evolution will likely vary depending on the partnership of interest.

Keywords: participatory, community-based participatory research, trust, social network analysis, social networks

Patient and Public Involvement Statement

This is one sub-study that is part of a larger study in which a Research Advisory Group was involved. This group comprises four research partners representing academic, service, or community organisations in the PPI Ignite Network (further described in this manuscript). These partners were a subset of individuals interested in this work, who were already working with co-authors JS, AM and MG through a prior grant called PPI Ignite@UL. These partners provided input and approval for the research objectives of this study, ensured all content in the network surveys and interview guide were both accessible to participants and contextually relevant, reviewed and interpreted findings at a high-level confirming from their perspective, if they agreed with the findings as a partner in the PPI Ignite Network, acted as a soundboard for brainstorming ways to address any research challenges, provided suggestions/feedback for ensuring dissemination materials and outputs (e.g., conference posters and manuscripts), and were being communicated effectively for diverse audiences. One Research

Advisory Group member has been further involved in the interpretation of the results as well as reviewing and revising manuscript content and language, and thus, authorship of this manuscript (co-author MMC). Co-author MMC was also involved in the dissemination of this work at an international conference (*cf* (1))

BACKGROUND

The value of a participatory approach to the generation of evidence for health and social services from a moral, methodological and policy level continues to develop on a global scale (2-4). Participatory Health Research (PHR) can be defined as "systematic inquiry, with the collaboration of those affected by the issue being studied, for the purposes of education and taking action or effecting change."(5)(pg.43) In PHR, "those affected" is intentionally broad encompassing any and all individuals, community members, or groups such as patients, public, health professionals, and organisational representatives. These individuals/groups can be both directly or indirectly affected by a health issue.(6) With roots grounded in principles of social action, justice and emancipatory philosophy, PHR has the potential to tackle complex health problems and achieve more meaningful and nuanced intermediate and long-term outcomes (6-8). Indeed, PHR has been gaining recognition throughout research communities as an approach that serves to bridge the gap between research and practice.(6, 8, 9) Specifically, PHR helps to maximise the relevancy of research and usability of its products, while simultaneously building capacity and addressing issues of social justice and self-determination among end-user communities.(6, 8) The central tenet of PHR is that it is a co-creation process. This means that those affected by the issue under investigation or who benefit from the knowledge being produced are key to the knowledge production process, working as equitable partners with academics from idea conceptualisation to dissemination and beyond (6, 10). In this paper, we discuss PHR as an

umbrella term for a variety of approaches (e.g., participatory action research (11), participatory rural appraisal (11, 12), community-based participatory research (CBPR)(13, 14)). Although these different terms may vary depending on the country of origin, discipline and research goals,(13, 15) they all strive to bridge the gap between knowledge and practice by harnessing inclusivity and recognising the importance of actively and meaningfully engaging those who the research serves to benefit in the research process (6).

One of the more widely recognised PHR approaches (6, 16), is CBPR. A CBPR conceptual model was developed(17) and adapted (8), which provides a concrete framework for understanding how the CBPR process is influenced by contextual and process-related aspects that can affect the ability to achieve both intermediate impacts (e.g. stronger partnerships) and long-term outcomes (e.g. improved health, community transformation, and health equity). The intention of the model is to act as a dynamic tool that evolves with research and understanding of CBPR. This includes a deeper understanding of how context, partnership characteristics, and processes contribute to research and intervention design, and ultimately lead to intermediate and long-term outcomes (18). However, challenges in operationalising aspects of the model limit our understanding and evaluation of the PHR process. For instance, Oetzel et al.(19, 20) noted that additional longitudinal research is required to better understand how CBPR processes lead to outcomes and under what conditions, to further substantiate the mechanisms in the model (19, 20).

Trust is frequently identified as an important component of the CBPR model, described as "permeating and affecting all interactions and relationships in the partnership and as linking one [domain] to another (21)(pg.14)." Trust has been underscored as a crucial mechanism (22, 23) essential to the PHR process that can affect the ability to achieve both intermediate impacts and long-term outcomes (24, 25). For example, seminal work by Jagosh et al.(23) found that the

building and maintenance of trust was a key mechanism for supporting partnership synergy, a universal feature of the collaborative process necessary for building and sustaining partnerships. However, defining, measuring and operationalising trust in PHR is challenging given the overwhelming variety of definitions associated with it (26). This reflects sentiments expressed by Misztal et al.(27)(pg.117), underscoring that of Wuthnow et al.(28), describing trust as "one of the most complex, multidimensional and misunderstood concepts in the social sciences (27, 28)(pg. 117)." As explicated by Lucero et al. (29), "although numerous CBPR scholars have discussed the importance of trust and offer anecdotal suggestions, very few systematically research it (pg. 160)." Influential work by Lucero et al.(25, 29, 30), has provided important advancements of trust in participatory literature presenting, for the first time to our knowledge, an alternative to the binary view of trust in CBPR (i.e., present or absent). As highlighted above, Lucero et al.(25, 29, 30) operationalised trust a typology of six categories from the lowest type being a trust deficit (suspicion) to the highest, called critical reflexive trust (having the ability to discuss and move on after a misstep). However, more work is still needed, especially exploring trust types over time.(25) With the recognition that trust is a dynamic, socially embedded process and extends beyond a simplified view as a variable, it requires a methodology that reflects this.(22)

One approach is to view PHR partnerships as a *social network.* A social network describes the relationships among people, organisations or other social actors (31). Social network analysis (SNA) is a methodology for describing and measuring contextual and relational dynamics among and between social actors (32). Trust is a type of relation that has been commonly explored in the network literature in diverse fields (33-49), such as in health (50) and education (51). As mentioned by Zolin and Gibbons,(49) "for a researcher, analysis of networks that are directly or indirectly related to trust may yield practical and theoretical insights that are not discoverable through other

means...(pg.189)". This is because, unlike other methods, SNA allows us to understand trust while embracing its social environment(49). This is a key strength of SNA as it extends beyond the behaviour of the individual, embracing the social aspects of behaviour. Using SNA we can then consider the interdependent nature of human data.(31, 52) Further, as trust is a type of relation, it is inherently embedded in a network of relationships. This creates opportunity to explore a variety of research questions about trust (49). For example, network questions can help us explore how trust is developed over time (49). Indeed, viewing PHR partnerships as a social network, applying SNA tools and techniques to explore trust over time, could help address the challenges that persist in operationalising trust in the CBPR model, and in turn, improve our understanding and evaluation of trust in the PHR process.

Recognising this potential, Gilfoyle et al.(53) proposed a novel and interdisciplinary conceptual triad with trust in the centre, connecting PHR and SNA, to explore how trust can be conceptualised, operationalised and measured in PHR and social networks literature. Results from this scoping review(53) revealed two key findings. Firstly, it found trust to be multidimensional, identifying several key trust dimensions, represented in Supplementary File 1. Secondly, it underscored a lack of conceptual and operational consistency of trust, particularly in the PHR literature. Gilfoyle et al.(54) then empirically tested the merits of exploring trust in a PHR partnership, known as the national Public and Patient Involvement (PPI) Ignite Network (see Setting below), comprehensively and in a multidimensional way. This revealed important nuances between the different dimensions of trust between partners who had national and local roles, which become diluted when explored in combination.

However, authors(54) were limited in that they explored trust cross-sectionally and without attention to specific attributes, such as partnership characteristics (e.g., local or national partners).

This is problematic because trust develops over time (22, 25, 30), and networks are dynamic as their membership and social contexts change (55). Further, network attributes, such as the roles of local or national partners, can influence collaborative behaviour (31), also warranting investigation over time. This is especially important in PHR where the importance of trust throughout all phases of the research process is underscored (21, 30), especially for ensuring partnerships are effective, equitable and long-term.(22, 25, 56, 57) Thus, if some types of partners (e.g., those who hold funding [cf (18)]) are developing trust and others (e.g., local partners) are not, important goals and ultimately outcomes of a partnership may be jeopardized. Addressing these limitations, this study seeks to extend the findings from Gilfoyle et al.(54), better understand the evolution of trust in the context of a participatory health research partnership (see setting below). This is done by exploring specific features of a participatory health research network (the national PPI Ignite Network in Ireland) asking:

1. Do the trust characteristics of the PPI Ignite Network change from T1 to T2?
2. Do the dimensions of trust identified differ at the local vs the national level? How did this evolve from T1 to T2?

METHODS

This study was granted ethics approval from the University of Limerick Education and Health Sciences Research Ethics Committee (#2021_03_16_EHS).

Setting

In 2017, five universities across Ireland were funded as individual *PPI Ignite Teams* by the Irish Health Research Board (HRB) and Irish Research Council (IRC) to build capacity for public and patient involvement (PPI) in health research. Building on and consolidating this work, the

HRB and IRC then funded the *PPI Ignite Network* (March 2021-2026), "aim[ing] to provide a shared voice for PPI across Ireland, aiming to change the research culture, and an important contributor to improving health outcomes for the public."

The PPI Ignite Network brings together academic, service and community organisations who co-designed the work programme and must collaborate in an efficient, synergistic and cohesive manner to plan, implement and evaluate the PPI initiatives set out by the network, of which trust is key (22-25). In particular there are five key areas of work set out by the network including, 1) building capacity for PPI in community and academic settings, 2) develop accredited education programmes for PPI, 3) enhance university policies and procedures to support PPI, 4) develop quality improvement and impact; and 5) create systems for national co-ordination and functioning (for further information on the PPI Ignite Network see: https://ppinetwork.ie/about-us/).

The PPI Ignite Network (n=57 at T1 and n=56 at T2 at time of sampling), a national PHR partnership, provides a useful setting to better understand how trust evolves in a PHR partnership over time. The PPI Ignite Network is comprised of seven universities called lead sites (five institutions involved previously as independent PPI Ignite Teams, plus two additional institutions), a national office, 10 national-level community partners who contribute to national-level governance and activities and 39 (at T1), and 38 (at T2) local-level partners who contribute to governance and activities at one university in the PPI Ignite Network. This administrative structure of the PPI Ignite Network resembles that of a hub and spokes model, with the national office at the center of the administrative structure, with connections to national partners as well as the seven universities. The universities are then connected further to local partners. With that in mind, the set-up of the PPI Ignite Network resources and decision-making pertaining to goals and objectives

were distributed across the network. The PPI Ignite Network functions as a participatory partnership where we explore the dimensions of trust in action for this study.

A Research Advisory Group consisting of four research partners representing academic, service, or community organisations in the PPI Ignite Network provided input and approval for the research objectives of this study and were similarly involved with three other sub-studies. These partners provided input and approval for the research objectives of this study, ensured all content in the network surveys and interview guide were both accessible to participants and contextually relevant, reviewed and interpreted findings at a high-level confirming from their perspective, if they agree with the findings as a partner in the PPI Ignite Network, provided suggestions/feedback for ensuring dissemination materials and outputs (e.g., conference posters and manuscripts) were being communicated effectively for diverse audiences. One Research Advisory Group member has been further involved in the interpretation of the results as well as reviewing and revising manuscript content and language, and thus, authorship of this manuscript (co-author MMC).

Data Collection

A social network can be defined as the set of connections among people, organisations or other social actors (31). This study invited all 57 (at T1) and 56 (at T2) individuals in the PPI Ignite Network to complete the same network survey at two time points. The first time point (T1) was near the commencement of the PPI Ignite Network in May 2021 and the second time point (T2) was a year later in May 2022. This timeframe was determined based on discussions with the Research Advisory Group, recognizing that the initial stages of partnership development are crucial for the trust building process (58), while also ensuring sufficient time had passed to build trust together. A network survey is a questionnaire used to generate names and connections among individuals in a network (31). The network survey in this study was designed based on the dimensions of trust identified by Gilfoyle et al.(53) and in collaboration with the Research

Advisory Group to ensure the appropriateness and readability of survey questions (See Supplementary File 2 for the Network Survey). The survey was administered electronically via Qualtrics software (Qualtrics software, Version May 2021 to December 2022). Survey questions included seven network questions that were found by Gilfoyle et al.(53), to be important dimensions of trust (shown in Supplementary File 1). To generate a network, each participant was asked to name up to seven organisations when answering the network survey questions (the same seven organisations for each question). They were asked to consider the *individual* in the network representing these organisations when responding to the network questions. This was a noteworthy distinction as we were interested in exploring the *partnership* collaboration and trust, not trust for the organisation.

The seven dimensions of trust their associated network questions were drawn from a scoping review by Gilfoyle et al.(53) that sought to comprehensively identify and synthesise how trust had been conceptualised and operationalised in both the PHR and social network literature, and if/where convergence existed. Gilfoyle et al.(53), incorporated a thematic analysis of the extracted literature, to more concretely elucidate the conceptual and operational linkages of trust across and within the PHR and social network literature. The relational constructs (i.e., sub-themes from this review) paralleled with discussions from the Research Advisory Group, informed the dimensions of trust identified in Supplementary File 1. A later study provided empirical support to the findings from the scoping review.(54)

Analysis

Individual networks for each dimension of trust were constructed from participant responses to the seven trust statements asked in the network survey at both time one (T1) and time two (T2). This was done by assigning a value from –1 to +1 depending on the selection of strongly

disagree to strongly agree (in intervals of 0.5 for the 5-point scale) for each trust statement. Specifically, when a participant responded 'agree', a weight of 0.5 was given to the edge, while 'strongly agree' scored an edge weight of 1. A connection (i.e., link in the network) was not added if participants responded with 'neither agree nor disagree', 'disagree', or 'strongly disagree' identifying only a presence of, or absence of, a trust connection. This is because, in alignment with the literature on trust, we did not want to infer neutral agreement or disagreement with each statement as an expression of *distrust*. Distrust is said to differ conceptually from trust (59) and more specifically stated by Jones (1996) "the absence of trust is not to be equated with distrust (60)."

Network Measures

Several network measures were used to analyse each of the seven trust dimensions at both T1 and T2. Specifically, *in-degree* which is the number of incident edges a node has, i.e., the number of times a node was nominated positively by another individual in the network. This helped us identify the trust relationships between people in a network, i.e. who trusts whom. Meanwhile, the *weighted in-degree* represents the total strength of agreement for each trust statement (described further in the analysis). Thus, the *average in-degree* reported in this paper looks at the mean number of received nominations across the network. This helped us identify how high trust is overall in the network. Moreover, the *average in-degree* allowed us to identify if the number of incoming edges received in the network as a whole (i.e., whether people agreed or strongly agreed with that specific dimension of trust) changes over time.

Clustering coefficient measures the proportion of closed triads (i.e., triangles) of a network (61), which allowed us to identify if a certain group is sharing trust throughout the network. *Reciprocity* at the network level is measured by the proportion of reciprocated edges in the network

(61). A reciprocated edge occurs when the edges between two nodes point in both directions. For example, if both individuals agreed or strongly disagreed with the same trust dimension between them, then this increases the reciprocity. The concept of reciprocity is often seen as a critical mechanism of trust (45, 56). *Freeman Centralisation about the in-degree* measures the importance (centrality) of a node (62). Specifically, a higher value for one (or a small number of) individuals suggests that they are in a position of power and control for that network. Comparatively, a *decentralised* network implies the opposite, where the power and control were distributed across many individuals. These measures allowed us to compare the structural properties of trust dimensions.

A separate network was also constructed including only the connections that were persistent in both timepoints. This allowed us to identify if the average in-degree and centralisation about the in-degree changed for individuals who selected the same people at both time points (i.e., was the rate of agreement the same over time when the same individual was selected in both timepoints. This enabled the comparison of how trust evolved over time for those who were naming new people in T2, to those who named the same people in T2.

Analysis of trust over time

To compare trust networks over time, we included responses from people that participated in both T1 and T2. First, we performed a two-sample Kolmogorov-Smirnov (KS) test on the degree distributions. This test was deemed appropriate as it is a non-parametric test for comparing two probability distributions. The KS statistic is generated by measuring the maximal difference between the cumulative form of the two distributions. It reports the difference between the distributions, allowing us to identify the degree to which certain trust networks differ over time. Although the degree distribution informs us about the nature of connections in the networks, it

does not tell us about further details such as who is connected to whom, or how participants connect (e.g., do participants with a low degree connect to others with a low degree or are they more likely to connect to those with a high degree).

We calculated the Hamming-Ipsen-Mikhailov (HIM) distance which is a metric that combines the Hamming distance (63, 64), which counts matching edges between two networks (i.e., trust dimensions at T1 and T2) and the Ipsen-Mikhailov distance, a spectral distance used to differentiate networks (65). Spectral distances are global measures that evaluate the difference between the whole structure, though can miss differences between small sub-structures. The HIM distance (66) yields a 0 if two networks are identical, or 1 if they are opposite. For example, a complete graph (a network where everyone is connected to everyone else) compared to a graph with no edges will have an HIM distance of 1.

Local vs National Partners

To identify if the trust dimension networks differed between local and national partners, we stratified each accordingly by type (i.e., local or national). Due to their small sample size and given their role in governing the national network, we combined the national office (n=1) and lead sites (n=7) with the national partners (n=10) into an overarching *national* category. We then calculated the network measures described above at both T1 and T2, to identify network changes over time for each local and national node.

RESULTS

In T1 (May 2021), 57 individuals from the PPI Ignite Network were invited to complete the network survey. Of these individuals, 43 (75%) participated. In T2 (May 2022), one organisation left the network, leaving 56 individuals invited to complete the same network survey. Of these 56 individuals, 33 (59%) participated. A breakdown of participation by

partnership type can be found in **Table 1** below.

Table 1: Response rate by partner type

	Time 1 - May 2021 (n=43)		Time 2 - May 2022 (n=33)	
Partnership Type	Count	Participation rate by partnership type	Count	Participation rate by partnership type
Site leads*	8	100%	7	88%
National partners*	8	80%	7	70%
Local partners	27	69%	19	50%

**Combined site leads and national partners for local vs. national analysis*

Table 2 below depicts the network level measures calculated at both T1 and T2 for the seven dimensions of trust, including new collaborations. We can see that over time, the number of connections (those who agree or strongly agree with that trust dimension) and the average in-degree (i.e., the number of incoming edges received) decreases. On average, participants receive approximately one less incoming connection compared to T1. In other words, people were agreeing and strongly agreeing slightly *less* often in time two for each statement of trust compared to T1. This decrease over time is also true for the mean clustering coefficient i.e., a decline in the number of trust triangles. For example, if person A agreed with a particular trust statement in T1 about persons B and C, it is likely B and C also agreed with that trust statement about each other, creating a triangular structure of connections in the network. However, in this case, the number of trust triangles declined, meaning it is less likely that B and C shared a trust connection at time two). Further, there was also a decline in the number of reciprocal connections at time two (where the trust connection goes both ways between two individuals, e.g., person A trust person B and vice versa) throughout the network. Indeed, for in-degree

centralisation, we note a very subtle *increase* across all trust dimensions, except for trust dimension 5 (shared values, visions, and goals) and trust dimension 7 (reciprocity). This means that over time, incoming trust connections are more concentrated on an individual/group of individuals. However, despite this subtle increase, overall, the networks appear decentralised at both time points.

In general, the magnitude of change for each network measure varies depending on the trust dimension. This underscores important nuances that are distinguishable when trust is explored multidimensionally. For example, trust dimension 6 (power sharing and co-ownership) reported one of the highest total number of connections (i.e., the statement of trust that people are most likely to agree/strongly agree with about another individual in the network) at both time points, while also being the trust dimension that had the greatest decrease in the number of connections over time (i.e., biggest change in agreement over time compared to other trust dimensions). Comparatively, trust dimension 2 (integrity), has one of the fewest number of connections at both time points (fewest people agreeing/strongly agreeing with the integrity statement), and the smallest change in connections over time (i.e., relatively consistent across timepoints). For other network measures, like the mean clustering coefficient (i.e., average number of trusted groups), we observe no change from T1 to T2 for trust dimension 4 (ability), yet a relatively large reduction for trust dimension 5 (shared values, visions, and goals) over time.

Network measures also reveal that some trust dimension networks are more alike. For example, we see that the network measures for trust dimension 1 (vulnerability) and trust dimension 2 (integrity), are similar to each other, as are trust dimension 5 (shared values, visions, and goals) and trust dimension 6 (power-sharing and co-ownership). Although dimensions 1 (vulnerability) and 2 (integrity) are similar to each other, they are notably different from trust

dimensions 5 (shared values, visions, and goals) and 6 (power-sharing and co-ownership). This finding is consistent over time.

Table 2: Network-level measures over time*

Networks (n=59)	Number of Edges		Weighted In-degree Mean (std)		Clustering Coefficient Mean (std)		Weighted In-degree Centralisation		Reciprocity	
	T1	*T2*	*T1*	*T2*	*T1*	*T2*	*T1*	*T2*	*T1*	*T2*
Trust Dimension 1[a] (Vulnerability)	66	**50**	1.98 (3.00)	**1.33 (2.29)**	0.10 (0.20)	**0.04 (0.11)**	0.23	**0.25**	0.28	**0.06**
Trust Dimension 2[b] (Integrity)	64	**53**	1.78 (2.84)	**1.54 (2.55)**	0.11 (0.23)	**0.04 (0.11)**	0.24	**0.29**	0.34	**0.19**
Trust Dimension 3[c] (Reliability)	103	**86**	3.61 (4.40)	**2.70 (4.09)**	0.13 (0.20)	**0.11 (0.18)**	0.33	**0.34**	0.37	**0.19**
Trust Dimension 4[d] (Ability)	83	**59**	2.65 (3.92)	**1.76 (2.72)**	0.06 (0.12)	**0.06 (0.14)**	0.26	**0.27**	0.29	**0.24**
Trust Dimension 5[e] (Shared values, visions, and goals)	130	**98**	4.17 (5.68)	**3.39 (4.80)**	0.20 (0.25)	**0.13 (0.21)**	0.41	**0.38**	0.45	**0.18**
Trust Dimension 6[f] (Power sharing and co-ownership)	126	**90**	3.91 (5.04)	**3.09 (4.53)**	0.16 (0.21)	**0.10 (0.17)**	0.35	**0.37**	0.43	**0.20**
Trust Dimension 7[g] (Reciprocity)	102	**75**	2.91 (3.92)	**2.26 (3.15)**	0.15 (0.24)	**0.11 (0.21)**	0.28	**0.23**	0.41	**0.21**

**This table includes all connections including new collaborations at time.* [2a]*Trust Network 1 question "I would discuss with [name of network member X] how I honestly feel about my work, negative feelings and frustrations",* [b]*Trust Network 2 question "[name of network member X] keeps my interest in mind when making decisions",* [c]*Trust Network question: "[name of network member X] is dependable. For example, they stick to their word and makes sure their actions and behaviours are consistent,* [d]*Trust Network 4 question:"I am comfortable asking [network member X] to take responsibility for project tasks even when I am not present to oversee what they do",* [e]*Trust Network 5 question:"I feel that [network member X] shares a vision with PPI Ignite Networks vision and goals?",* [f]*Trust Network 6 question:"I feel that [network member X] is open to discussion* about matters pertaining to the PPI Ignite Network",* [g]*Trust Network 7 question: "I feel that [network member X] trusts me"*

Kolmogorov-Smirnov (KS) test

After calculating the KS statistic, a non-parametric test for comparing two probability distributions, we do not find a statistically significant difference for the in-degree distribution across any of the trust dimensions from T1 to T2, implying that the two samples are drawn from the same in-degree distribution. This is expected, as we hope participants are naming other participants in the same manner at each time point, rather than, for example, choosing thoughtfully at T1 and randomly at T2. However, we do find that the KS statistic is larger for certain trust dimension networks, indicating some variation over time for some trust dimension networks compared to others. For example, trust dimensions 3 (reliability) and 6 (power sharing and co-ownership), has the largest KS statistic at 0.20, while trust dimension 2 (integrity) has the smallest KS statistic, 0.09. For plots see Supplementary File 3. Therefore, although changes in the KS statistic are subtle overall, they vary across the different trust dimensions.

Hamming and Ipsen-Mikhailov (HIM) distance

As our networks have a low density of connections, we recognize that HIM distance, exploring whether connections between individuals change over time, will never be close to one. Therefore, we are not as interested in the overall magnitude of the value, but each HIM distance relative to that of other trust dimensions. We see a small range in HIM distance across the dimensions of trust with an HIM distance ranging from 0.08 – 0.12. Specifically, we observe that networks for trust dimension 2 (integrity) (HIM = 0.08) are more similar from T1 to T2 compared to trust dimension 5 (shared values visions and goals) (HIM = 0.12). See Supplementary File 4 for further details.

Indeed, both the KS statistic and HIM distance underscore greater differences across each dimension of trust, than within each dimension from T1 to T2.

Local vs National Comparison

Findings for the weighted mean in-degree and clustering coefficient by type of node (local vs national) T1 and T2, are presented in **Table 3** below. We can see a decrease in weighted mean in-degree (i.e., average number of incoming connections) at both time points for local and national nodes. However, the weighted mean in-degree is higher for national partners than the local partners at both time points, across all trust dimensions. This implies that individual who are national partners or site leads in the PPI Ignite Network, have more trust nominations, i.e., more people agreeing/strongly agreement with the trust statements about them, compared to local partners. We note the largest difference between local vs national partners for trust dimension 5 (shared values, visions, and goals) across both T1 and T2, while trust dimension 2 (integrity) shows the smallest difference between local vs national partners over both T1 and T2. Comparatively, the clustering coefficient does not show such consistent trends across node type, with some local partners having a higher clustering coefficient (i.e., trust triangles) compared to national partners at T1 but a lower clustering coefficient at T2 (see trust dimensions 1 (reliability), 5 (shared values, visions, and goals), 6 (power sharing and co-ownership), and 7 (reciprocity)).

Table 3: Network Measures for Trust Dimensions at T1 and T2 stratified by Local vs National Node Type

	Node Type (Local [n=27] and National [n=15])	**Weighted In-degree Mean (std)**		**Clustering Coefficient**	
		Time 1	**Time 2**	**Time 1**	**Time 2**
Trust Dimension 1[a] (Vulnerability)	*Local Nodes*	0.55 (0.94)	**0.27 (0.54)**	0.11 (0.23)	**0.07 (0.16)**
	National Nodes	4.40 (4.06)	**3.27 (3.11)**	0.11 (0.16)	**0.03 (0.05)**
Trust Dimension 2[b] (Integrity)	*Local Nodes*	0.59 (0.94)	**0.36 (0.64)**	0.11 (0.23)	**0.03 (0.11)**
	National Nodes	4.00 (3.95)	**3.80 (3.37)**	0.13 (0.26)	**0.08 (0.13)**
Trust Dimension 3[c] (Reliability)	*Local Nodes*	1.50 (1.31)	**0.77 (1.00)**	0.16 (0.25)	**0.10 (0.21)**
	National Nodes	7.20 (5.96)	**6.60 (5.17)**	0.11 (0.13)	**0.18 (0.16)**
Trust Dimension 4[d] (Ability)	*Local Nodes*	0.63 (0.87)	**0.45 (0.72)**	0.04 (0.11)	**0.01 (0.05)**
	National Nodes	6.20 (5.44)	**4.33 (3.42)**	0.09 (0.08)	**0.17 (0.20)**
Trust Dimension 5[e] (Shared values, visions and goals)	*Local Nodes*	1.50 (1.34)	**1.18 (1.53)**	0.27 (0.30)	**0.15 (0.27)**
	National Nodes	9.20 (7.58)	**7.93 (6.02)**	0.17 (0.17)	**0.17 (0.14)**
Trust Dimension 6[f] (Power sharing and co-ownership)	*Local Nodes*	1.63 (1.33)	**1.00 (1.31)**	0.20 (0.25)	**0.08 (0.20)**
	National Nodes	8.20 (6.82)	**7.40 (5.69)**	0.15 (0.15)	**0.16 (0.14)**
Trust Dimension 7[g] (Reciprocity)	*Local Nodes*	1.18 (1.11)	**0.81 (1.11)**	0.19 (0.27)	**0.12 (0.27)**
	National Nodes	6.20 (5.29)	**5.27 (3.86)**	0.16 (0.25)	**0.16 (0.16)**

[a]*Trust Network 1 question"I would discuss with [name of network member X] how I honestly feel about my work, negative feelings and frustrations",* [b]*Trust Network 2 question"[name of network member X] keeps my interest in mind when making decisions",* [c]*Trust Network question: "[name of network member X] is dependable. For example, they stick to their word and makes sure their actions and behaviours are consistent,* [d]*Trust Network 4 question:"I am comfortable asking [network member X] to take responsibility for project tasks even when I am not present to oversee what they do",* [e]*Trust Network 5 question:"I feel that [network member X] shares a vision with PPI Ignite Networks vision and goals?",* [f]*Trust Network 6 question:"I feel that [network member X] is open to discussion* about matters pertaining to the PPI Ignite Network",* [g]*Trust Network 7 question: "I feel that [network member X] trusts me"*

Figure 1 illustrates the networks for these two trust dimension networks over time. We can see that the networks appear less "dense" for trust dimension 2 (integrity) over time, and denser

for trust dimension 5 (shared values, visions, and goals). This tells us that people's rate of agreement is different for across these trust dimensions, which is an important nuance detected when explored as distinct networks. We can also see that more nodes are disconnected from the networks in T2 compared to T1 for both dimensions of trust. However, this is more obvious for Trust Dimension 2 (integrity). This implies that the trust connection for these disconnected nodes no longer exists at T2 for that dimension of trust.

Figure 1: Networks for Trust Dimension 2 (Integrity) and 5 (Shared values, visions, and goals) at T1 and T2

[insert here]

Persistent Connections in T1 and T2

Findings comparing network measures of persistent connections (i.e., the same person nominated in time one and T2 are outlined in Table 4[1] below. In this specific analysis, if people were collaborating with and thus nominating new individuals in T2, they were removed from this analysis. This allowed us to compare trust connections that were persistent overtime. Interestingly, the average number of weighted incoming connections across all trust dimensions increased over time. This implies that people's rate of agreement (for those they *also* almost nominated in T1) increased.

Table 4: Network-level measures over time*

Networks (n=59)	**Weighted In-degree Mean (std)**		**Weighted In-degree Centralisation**	
	T1	***T2***	***T1***	***T2***
Trust Dimension 1[a] (Vulnerability)	0.85 (1.74)	**1.02 (1.88)**	0.17	**0.16**

[1] Non-weighted properties such as clustering coefficient and reciprocity are not included as they would not change over time as we are only including persistent connections.

Trust Dimension 2[b] (Integrity)	0.83 (1.89)	**1.09 (2.10)**	0.17	**0.18**
Trust Dimension 3[c] (Reliability)	1.57 (2.64)	**1.89 (3.01)**	0.22	**0.24**
Trust Dimension 4[d] (Ability)	1.09 (2.04)	**1.37 (2.34)**	0.21	**0.20**
Trust Dimension 5[e] (Shared values, visions, and goals)	2.02 (3.02)	**2.37 (3.60)**	0.23	**0.29**
Trust Dimension 6[f] (Power sharing and co-ownership)	1.98 (3.00)	**2.30 (3.59)**	0.23	**0.30**
Trust Dimension 7[g] (Reciprocity)	1.26 (2.29)	**1.67 (2.65)**	0.18	**0.19**

**This table explores connections that were persistent over time (i.e., excludes new collaborations in T2).* [a]*Trust Network 1 question "I would discuss with [name of network member X] how I honestly feel about my work, negative feelings and frustrations",* [b]*Trust Network 2 question "[name of network member X] keeps my interest in mind when making decisions",* [c]*Trust Network question: "[name of network member X] is dependable. For example, they stick to their word and makes sure their actions and behaviours are consistent,* [d]*Trust Network 4 question:"I am comfortable asking [network member X] to take responsibility for project tasks even when I am not present to oversee what they do",* [e]*Trust Network 5 question:"I feel that [network member X] shares a vision with PPI Ignite Networks vision and goals?",* [f]*Trust Network 6 question:"I feel that [network member X] is open to discussion* about matters pertaining to the PPI Ignite Network",* [g]*Trust Network 7 question: "I feel that [network member X] trusts me"*

In summary, findings highlighted:

- An SNA approach identified subtle changes over time in when exploring trust multidimensionally in the PPI Ignite Network. On average there was a slight decrease in trust connections for each dimension of trust from T1 to T2 on a global level. However, trust connections that were persistent over time, increased across all dimensions of trust.
- More distinct differences are present when stratifying trust across the dimensions by partnership type (i.e., local or national partner), where national partners and site leads in the

PPI Ignite Network, have more trust nominations, i.e., more people agreeing/strongly agreement with the trust statements about them, compared to local partners.

- These findings suggest an edit to the current conceptual view of trust as illustrated in Supplementary File 1, replacing it with a more dynamic, multidimensional representation of trust depicted in Supplementary File 5.

DISCUSSION

This study extends the work by Gilfoyle et al., (53, 54) by comparing the dimensions of trust over time, by local or national partnership type, and more broadly, by contributing to the conceptual and operational gaps surrounding trust in participatory research partnerships (53, 54). By analysing the different dimensions of trust as separate networks, we can identify where they change over time. We provide empirical support for a comprehensive and multidimensional exploration of trust as it evolved in the PPI Ignite Network, detecting subtle changes across most network measures over time. We could see a general decrease in the number of connections for each dimension of trust over time across the PPI Ignite Network. However, trust connections that were persistent over time, increased across all dimensions of trust. This suggests that when partnerships were maintained from T1 to T2, trust increased. Comparatively, across the PPI Ignite Network trust decrease slightly, likely due to new formed collaborations, where trust had yet to be established/sustained. This is persistent with the literature which suggests trust must be built and sustained over time, and new collaborations/change in personnel can impact its development and maintenance (22, 67).

We also found that some networks were more similar (i.e., vulnerability and integrity) and others strikingly different (integrity and shared values, visions, and goals) to each other, with a higher number of incoming connections for national partners compared to local partners. These

findings provide important contributions to the literature, namely providing empirical support for using SNA to operationalise trust in a comprehensive and multidimensional over time in a PHR partnership. This is key as PHR advocates for contextually derived and driven knowledge production, to suit the needs of the communities (8, 68) and is underscored in the CBPR conceptual model (18). Therefore, operational techniques must also consider the context of the partnership so that partners can both understand and evaluate if the goals of the partnership are being met and if they are on a trajectory of success. This can be a limitation of more traditional quantitative analytical approaches, creating challenges for measuring context across partnerships (69). This is a key strength of SNA tools and techniques, which embrace the individual and system-level perspective, when exploring complex social-relational processes, like trust, while considering the social context and how it influences individuals within it (70).

Using SNA also provided us with "insight into the relationships, positions, structure and strength of a network (71)(pg.4)" across two time points. We could see where trust relations did or did not exist in the PPI Ignite Network over time through the network maps *and* understand the implications of individual positions and the network structure as whole. For example, central actors are thought to have more prestige, visibility and influence in a network, and are often viewed as opinion leaders that are key to the diffusion of ideas and behaviour (31). This has important implications for the trust development process, highlighting areas for structural intervention (i.e., strategic actions that or remove links between nodes (72)). Specifically, findings could help partners capitalise on strong connections and address areas of weakness to ensure trust is built and maintained over time. Indeed, understanding the trust development process is a current gap in the PHR literature, where "the majority of trust and community-based participatory research literature conceptualised trust as an outcome and acknowledges that research on trust development is lacking

(29)(pg.62).” An enhanced understanding of the trust development process could in turn dictate where (often limited) time and resources are spent to improve trust in partnerships, and ultimately partnership functioning. For example, considering the finding that local partners were less central compared to national partners (i.e., had fewer incoming nominations across each dimension of trust), we could recommend immediate interventions, like creating opportunity for local partners to lead on work. However, if partnership capacity is an issue, interventions such as the (re)distribution of resources and support to local partners would be needed. Indeed, we could use SNA to both operationalise and then evaluate trust comprehensively and consistently over time. For instance, the network maps provide a visual representation of each trust dimension for the PPI Ignite Network over a 1-year timepoint, which could be used mode for evaluating the trust development process. For instance, findings could be presented and discussed with members of the PPI Ignite Network to ensure they, a) adequately reflect their experience of trust in the PPI Ignite Network, and b) to better understand why trust may have evolved as it did over the course of 1 year. As trust is key to achieving successful outcomes in a partnership (23, 73), this would be especially important for networks like the PPI Ignite Network who have committed to working together over the course of 5 years.

Limitations

Although embracing context is important, readers should consider this when interpreting and/or applying findings to their own research. This case study used a small network with two time points over a year. Considering trust takes time to develop, it is possible that surveying trust at only two time points over a year is restrictive. Further, as trust is inherently contextual, its evolution will likely vary depending on the partnership of interest.

Future Research

Areas of future work could include exploring whether trust conceptualised and operationalised in the PPI Ignite Network led to better partnership outcomes. Also, we could identify additional network features that might be influential for trust in PHR, such as asymmetry in relationships. In addition, future research could explore whether certain trust dimensions (i.e., of the 7 dimensions) are more relevant or pertinent to specific aspects of the CBPR model. We also hope to explore the trust development process across other PHR partnerships, to compare findings across multiple study contexts.

CONCLUSION

This study utilises a novel and interdisciplinary lens, drawing from both the social network and PHR literature, to further clarify important conceptual and operational complexities of trust. In doing so, we were able to extend findings of Gilfoyle et al.(53, 54), analysing trust consistently and comprehensively *over time* in a real-world partnership, the PPI Ignite Network. Findings provide empirical support for employing SNA to explore the evolution of trust as a multidimensional concept in PHR partnerships over time. Future research could consider exploring trust over a longer period of time, to better understand the evolution of trust in their context.

AUTHOR CONTRIBUTIONS

All authors have made substantive intellectual contributions to the development of this study. MG conceptualized and led the study, drafted, and edited the final manuscript. PMC analysed the data and contributed to the study design, data analysis and interpretation, writing, and editing of the manuscript. JS secured funding, contributed to the study conceptualisation, data analysis and interpretation, and contributed to the writing and editing of the final manuscript. AMF contributed to the study conceptualisation, writing, and editing of the final manuscript. MMC contributed to study conceptualisation, interpretation of results, reviewed and approved manuscript.

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COMPETING INTERESTS

None declared.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author, JS, upon reasonable request.

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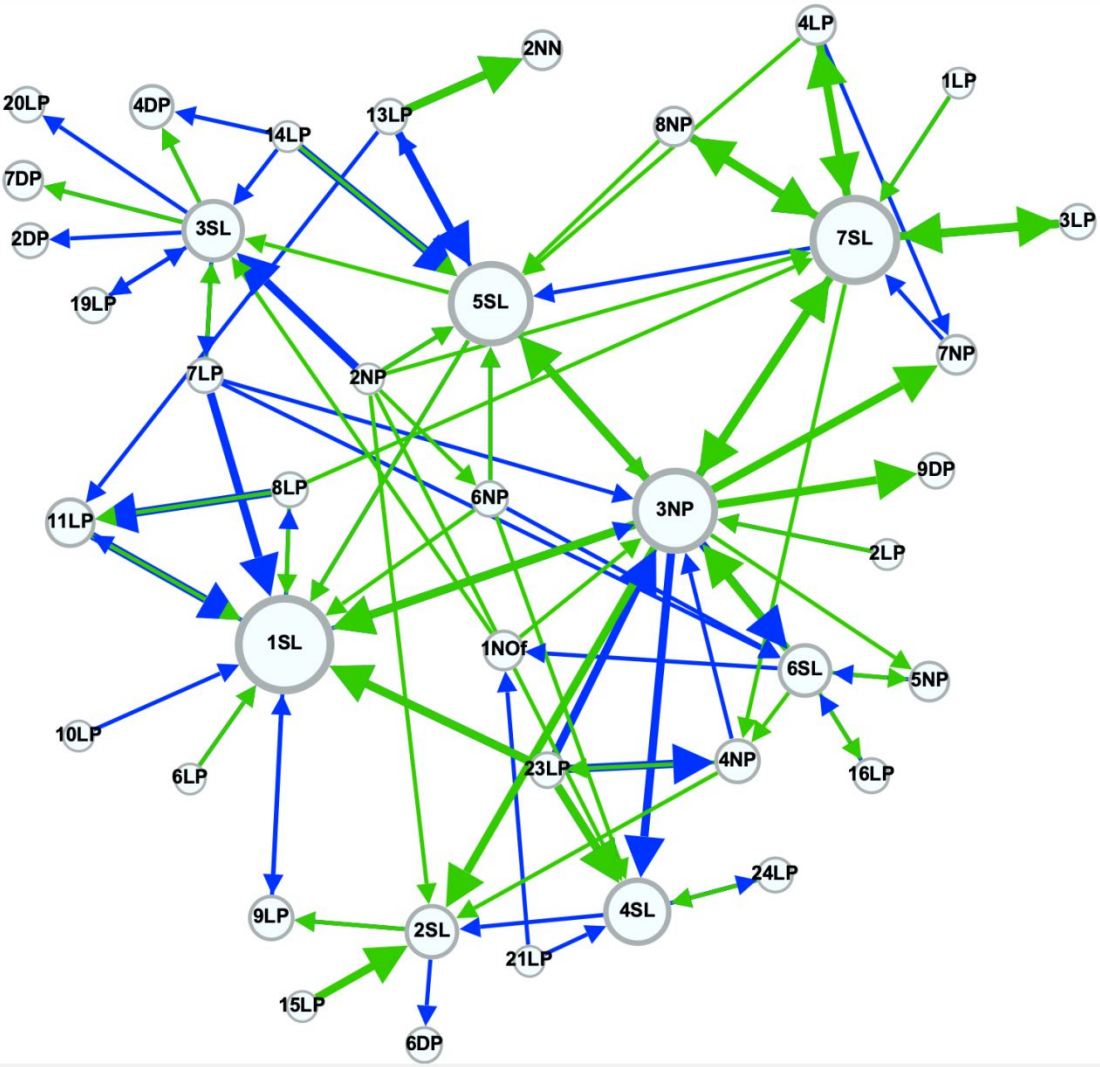
List of Figures (1):

Figure 1: Networks for Trust Dimension 2 (Integrity) and 5 (Shared values, visions, and goals) at T1 and T2

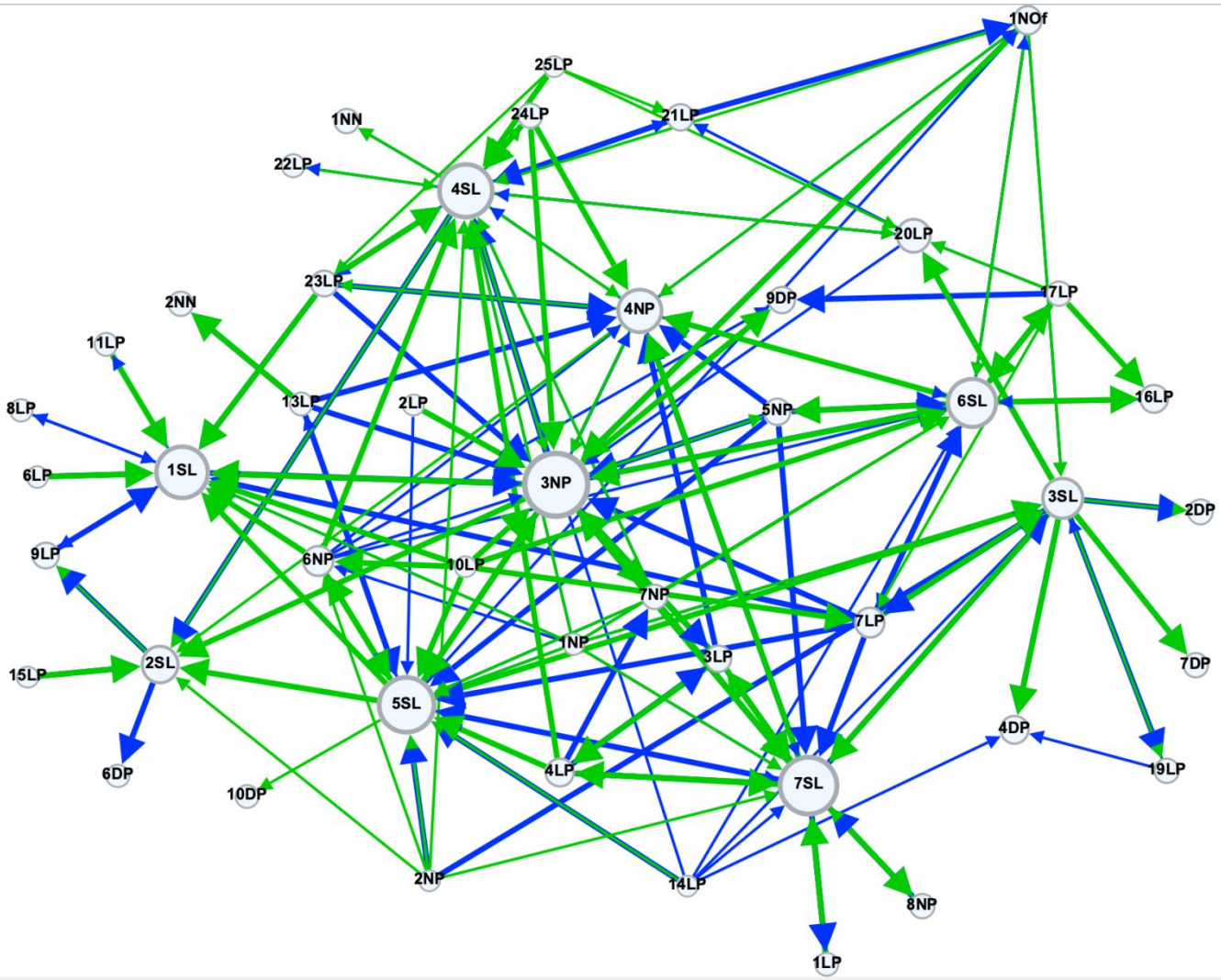
Figure 1: Networks for Trust Dimension 2 (Integrity) and 5 (Shared values, visions, and goals) at T1 and T2

Trust Dimension 2 - Integrity



Note: Blue arrows indicate T1 connections. Green arrows indicate T2 connections. The size of the node pertains to the number of incoming nominations for that individual. A larger node has more people 'agreeing' or 'strongly agreeing' with that statement of trust about them. NP = National Partner; LP = Local Partner; SL = Site Lead; DP = nominated but did not participate in network survey; NN = nominated but not in the PPI Ignite Network.

Trust Dimension 5 – Shared Values, Visions and Goals



Note: Blue arrows indicate T1 connections. Green arrows indicate T2 connections. The size of the node pertains to the number of incoming nominations for that individual. A larger node has more people 'agreeing' or 'strongly agreeing' with that statement of trust about them. NP = National Partner; LP = Local Partner; SL = Site Lead; DP = nominated but did not participate in network survey; NN = nominated but not in the PPI Ignite Network.

Supplementary File 1: A Multidimensional View of Trust

Supplementary File 1 description**:** The figure displays the 7 dimensions of trust as identified in the scoping review by Gilfoyle et al.(1) The network survey in this study was designed based on these dimensions, with a collaboration question acting as the *name generator* (2) for the network survey.

References

1. Gilfoyle M, MacFarlane A, Salsberg J. Conceptualising, operationalising, and measuring trust in participatory health research networks: a scoping review. Systematic Reviews. 2022;11(1):40.
2. Burt RS. Network items and the general social survey. Social networks. 1984;6(4):293-339.

(Time 1) Network Survey and Framing Questions - PPI Network

Start of Block: Information sheet and consent form

Information Sheet **Before continuing, please review the information sheet for volunteers by clicking the link below:**

LINK: [removed for peer review]

[consent form removed for peer review]

Consent By clicking 'Yes' below, I am providing my consent to participate as indicated above OR click 'No' below, if you choose not to participate at this time.

- ○ **Yes, I consent to participate** (1)
- ○ **No, I choose not to participate at this time** (2)

End of Block: Information sheet and consent form

Start of Block: Network Questions Part 1

JS

Question 1

Thank you for taking part in this study!

You have read the study information letter and have signed an informed consent form, so you understand the purpose of the study and the use to which its findings will be put.

Individuals and institutions will be anonymised in all wider reporting of results.

This questionnaire should take approximately 15 minutes to complete.

Section 1: Network Questions

Level of Collaboration

For the following questions we are asking you to name organisations you are collaborating with on the PPI Ignite Network. When choosing an organisation, think about the specific individuals that represent the organisation in the network. *For example, if you were collaborating with [example name].*

Once you start typing an organisation's **full** name, an auto fill drop-down box will appear. Select the organisation you want. If needed, click here for a full list of network organisations.

Question 1:

a. Enter up to 7 organisations that you collaborate with on the PPI Ignite Network.

b. Beside each of the selected organisations, rank your intensity of collaboration.

(Please refer to Table A to guide your ranking)

Table A

Level **Definition** **(0) No interaction** No interaction, not aware of individual in this organisation

(1) Networking I am aware of the individual(s), but we have loosely defined roles, little communication, and all decisions made independently

(2) Cooperation We provide information to each other, have somewhat defined roles, formal communication, but all decisions are made independently

(3) Coordination We share information and resources, have defined roles, frequent communication, some shared decision making

(4) Coalition We share ideas and resources, have frequent and prioritised communication, and have a vote in each other's decision making

(5) Collaboration We belong to one system, our frequent communication is characterized by mutual trust, consensus is reached on all decisions

	0 No Interaction (1)	**1 Networking** (2)	**2 Cooperation** (3)	**3 Coordination** (4)	**4 Coalition** (5)	**5 Collaboration** (6)
Type organization 1 here: (1)	○	○	○	○	○	○
Type organization 2 here: (2)	○	○	○	○	○	○
Type organization 3 here: (3)	○	○	○	○	○	○
Type organization 4 here: (4)	○	○	○	○	○	○
Type organization 5 here: (5)	○	○	○	○	○	○
Type organization 6 here: (6)	○	○	○	○	○	○
Type organization 7 here: (7)	○	○	○	○	○	○

End of Block: Network Questions Part 1

Start of Block: Network Questions Part 2

Statement 1 **Relational questions about 7 PPI Ignite Network Members** For each of the organisation names (up to 7) you listed in Question 1, please answer the following:

Question 2: On a scale from (1) strongly disagree to (5) strongly agree, please rate the extent to which you agree with the following 7 statements:

**Note: statement 6 has additional descriptions to help guide your selection*

	1 Strongly Disagree (1)	**2 Disagree** (2)	**3 Neither agree nor disagree** (3)	**4 Agree** (4)	**5 Strongly agree** (5)
${Question 1/ChoiceTextEntryValue/1} (1)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/2} (2)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/3} (3)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/4} (4)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/5} (5)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/6} (6)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/7} (7)	○	○	○	○	○

Statement 5 .

	1 Strongly Disagree (1)	**2 Disagree** (2)	**3 Neither agree nor disagree** (3)	**4 Agree** (4)	**5 Strongly agree** (5)
${Question 1/ChoiceTextEntryValue/1} (1)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/2} (2)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/3} (3)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/4} (4)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/5} (5)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/6} (6)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/7} (7)	○	○	○	○	○

Statement 6 .

	1 Strongly Disagree (1)	2 Disagree (2)	3 Neither agree nor disagree (3)	4 Agree (4)	5 Strongly agree (5)
${Question 1/ChoiceTextEntryValue/1} (1)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/2} (2)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/3} (3)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/4} (4)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/5} (5)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/6} (6)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/7} (7)	○	○	○	○	○

Statement 7 .

	1 Strongly Disagree (1)	**2 Disagree** (2)	**3 Neither agree nor disagree** (3)	**4 Agree** (4)	**5 Strongly agree** (5)
${Question 1/ChoiceTextEntryValue/1} (1)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/2} (2)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/3} (3)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/4} (4)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/5} (5)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/6} (6)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/7} (7)	○	○	○	○	○

Statement 8 .

	1 Strongly Disagree (1)	2 Disagree (2)	3 Neither agree nor disagree (3)	4 Agree (4)	5 Strongly agree (5)
${Question 1/ChoiceTextEntryValue/1} (1)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/2} (2)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/3} (3)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/4} (4)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/5} (5)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/6} (6)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/7} (7)	○	○	○	○	○

Statement 9 .

	1 Strongly Disagree (1)	2 Disagree (2)	3 Neither agree nor disagree (3)	4 Agree (4)	5 Strongly agree (5)
${Question 1/ChoiceTextEntryValue/1} (1)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/2} (2)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/3} (3)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/4} (4)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/5} (5)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/6} (6)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/7} (7)	○	○	○	○	○

Statement 10

	1 Strongly Disagree (1)	2 Disagree (2)	3 Neither agree nor disagree (3)	4 Agree (4)	5 Strongly agree (5)
${Question 1/ChoiceTextEntryValue/1} (1)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/2} (2)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/3} (3)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/4} (4)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/5} (5)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/6} (6)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/7} (7)	○	○	○	○	○

End of Block: Network Questions Part 2

Start of Block: Framing Questions

Trust typology **Section 2 – Framing Questions**

Trust typology In this Question, we are interested in learning your views on **the type of trust** you think exists in the PPI Ignite Network at this point in time. The six trust types and their associated definition **are listed below. Question 3: Please indicate your views on trust in the PPI Ignite Network at this time. Specifically, what type of trust do you think currently exists in the network?**

CLICK ONE OF THE FOLLOWING:

- **Critical reflexive trust** (Trust that allows for mistakes and where differences can be talked about and resolved) (1)
- **Proxy trust** (Partners are trusted because someone trusted invited them) (2)
- **Functional trust** (Partners are working together for a specific purpose and time-frame, but trust may still be present) (3)
- **Neutral trust** (Partners are still getting to know each other there is neither trust nor mistrust) (4)
- **Unearned trust** (Trust is based on member's title or role with limited or no direct interaction) (5)
- **Trust deficit (suspicion or mistrust)** (Partnership members do not trust each other) (6)

---

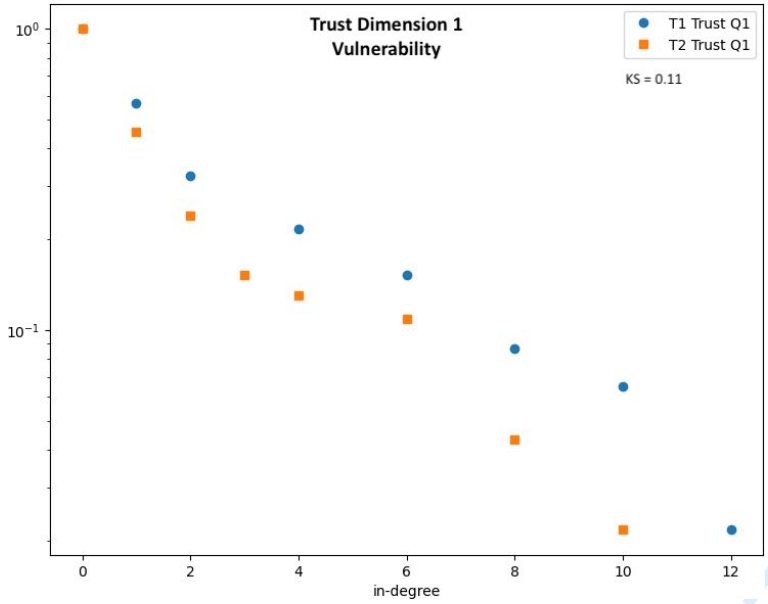
preparedness **PPI preparedness question Question 4: On a scale from (1) strongly disagree to (5) strongly agree, please rate the extent to which you agree with the following statement:** ***"I feel my organisation is prepared to support PPI research at this time"***

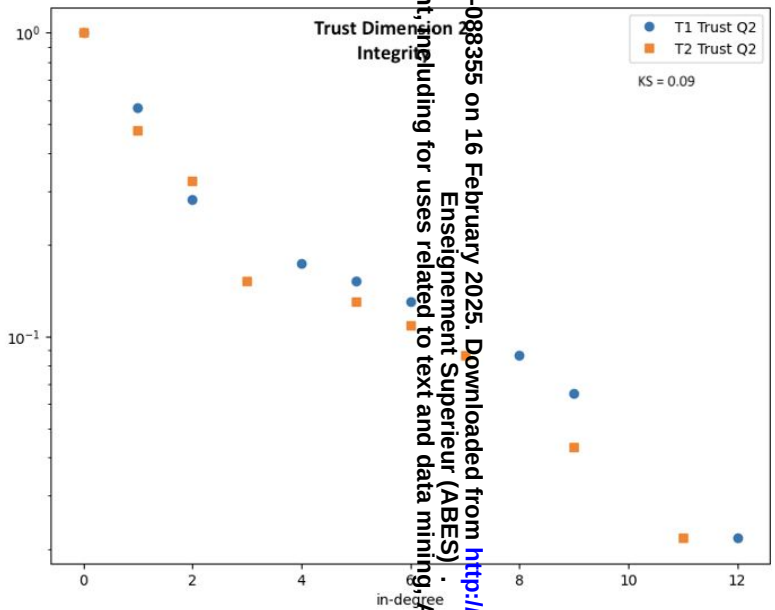
CLICK ONE OF THE FOLLOWING:

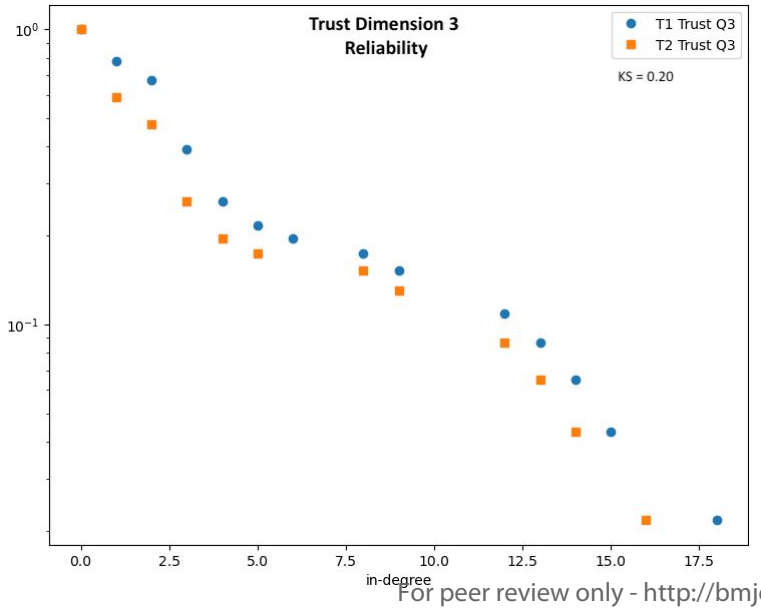
- **1 Strongly disagree** (1)
- **2 Disagree** (2)
- **3 Neither agree nor disagree** (3)
- **4 Agree** (4)
- **5 Strongly agree** (5)

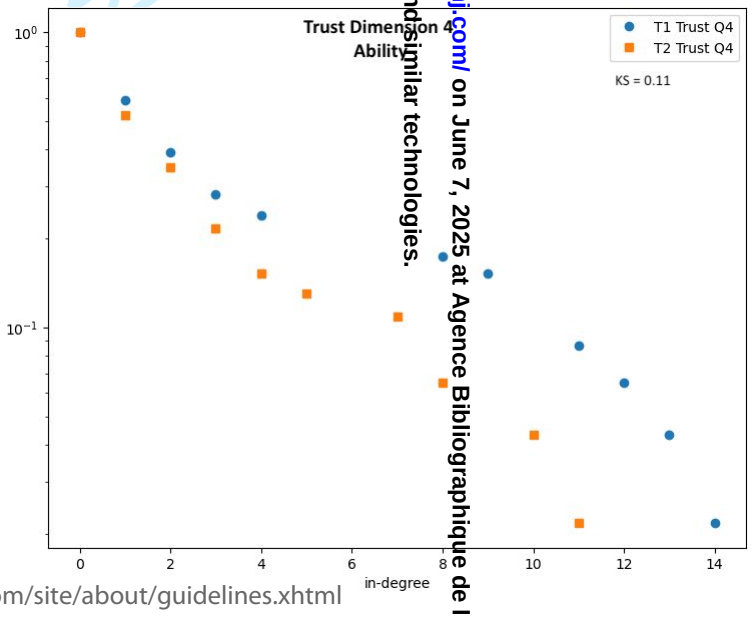
End of Block: Framing Questions

Distribution plots and Kolmogorov-Smirnov test

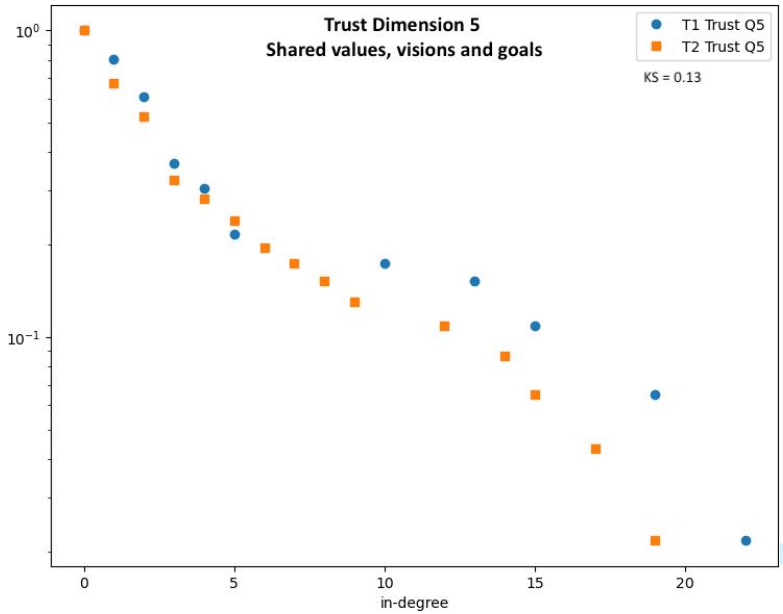


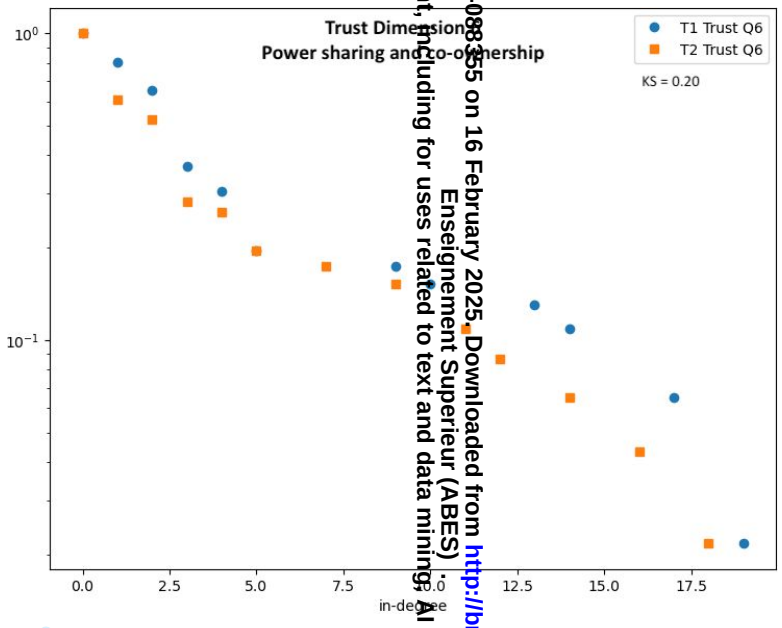


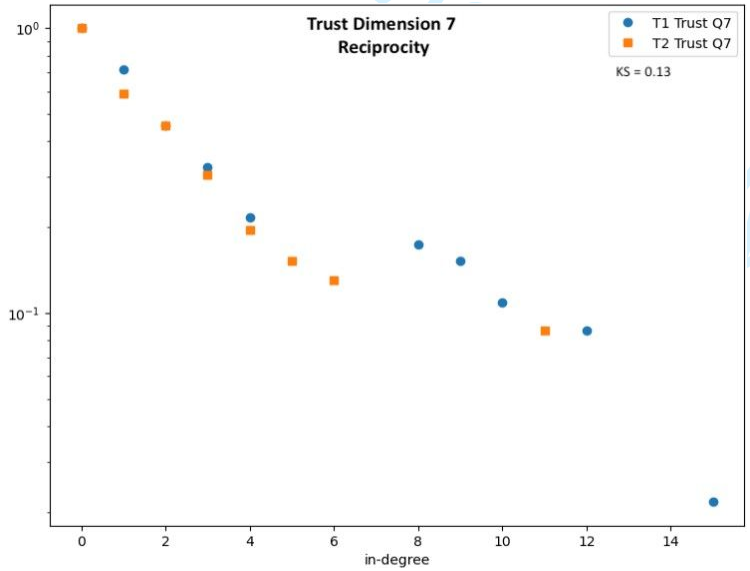




Distribution plots and Kolmogorov-Smirnov test

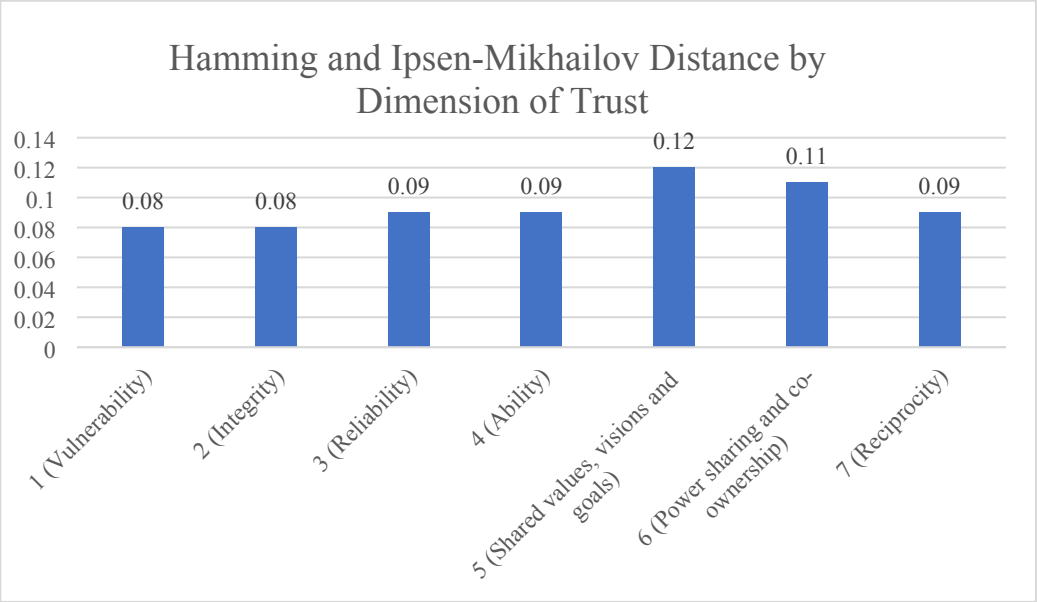






Distribution plots and Kolmogorov-Smirnov test

Hamming and Ipsen-Mikhailov Distance by Dimension of Trust Over Time



This metric combines the Hamming distance (Deza and Deza, 2009; Gao et al., 2010), which counts matching connections between two networks (i.e., trust dimensions at T1 and T2) and the Ipsen-Mikhailov distance, a spectral distance used to differentiate networks.(Ipsen and Mikhailov, 2003) Spectral distances are global measures that evaluate the difference between the whole structure, though can miss differences between small sub-structures. The HIM distance (Jurman et al., 2015) yields a 0 if two networks are identical, or 1 if they are opposite. For example, two networks that are identical will have a HIM distance of 0, while a complete graph (a network where everyone is connected to everyone else) compared to a graph with no connections, will have an HIM distance of 1.

References:

Deza MM and Deza E (2009) Encyclopedia of distances. *Encyclopedia of distances*. Springer, pp.1-583.

Gao X, Xiao B, Tao D, et al. (2010) A survey of graph edit distance. *Pattern Analysis and applications* 13(1): 113-129.

Ipsen M and Mikhailov AS (2003) Erratum: Evolutionary reconstruction of networks [Phys. Rev. E 66, 046109 (2002)]. *Physical review E* 67(3): 039901.

Jurman G, Visintainer R, Filosi M, et al. (2015) The HIM glocal metric and kernel for network comparison and classification. *2015 IEEE international conference on data science and advanced analytics (DSAA)*. IEEE, 1-10.

Supplementary File 5: A Multidimensional and Dynamic View of Trust

Supplementary File 5: This updated figure displays the 7 dimensions of trust as identified in the scoping review by Gilfoyle et al., with arrows added to depict the dynamic nature of trust, also underscored in this work when applying a SNA approach to operationalise trust multidimensionally and over time.

References

1. Gilfoyle M, MacFarlane A, Salsberg J. Conceptualising, operationalising, and measuring trust in participatory health research networks: a scoping review. Systematic Reviews. 2022;11(1):40.

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An Exploration of Trust in Participatory Health Research Partnerships Across Two Timepoints – A Network Approach

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Primary Subject Heading:	Health services research
Secondary Subject Heading:	Research methods
Keywords:	Community-Based Participatory Research, Health, SOCIAL MEDICINE

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An Exploration of Trust in Participatory Health Research Partnerships Across Two Timepoints – A Network Approach

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ABSTRACT

Background: The value of a participatory approach to the generation of evidence for health and social services from a moral, methodological and policy level continues to gain recognition globally. Trust is a crucial mechanism in the participatory health research (PHR) process and is strongly influenced by context. However, gaps remain in conceptualising and operationalising trust over time in PHR partnerships.

Objective: This case study seeks to address these gaps by exploring the evolution of trust multidimensionally across two timepoints.

Setting and Participants: Participants in a PHR project called the Public and Patient Involvement (PPI) Ignite Network in Ireland (n=57 (T1); n=56 (T2)) were invited to complete a network survey at two timepoints. The PPI Ignite Network had local and national partners.

Network Measures: Several core social network measures were calculated at both timepoints to characterize differences between trust dimensions and between local and national partners.

Results: Subtle changes were observed across most network measures over the two timepoints. While there was a slight decrease in the number of connections for each trust dimension throughout the PPI Ignite Network, connections that were consistently nominated in both timepoints increased slightly. Some trust dimensions, such as vulnerability and integrity, were more similar, while others, like integrity and shared values, visions, and goals, differed greatly, where national partners consistently received more incoming connections compared to local partners.

Conclusion: These findings, 1) provide empirical support for using Social Network Analysis (SNA) to operationalise trust comprehensively and multidimensionally over time in a participatory partnership, 2) offer nuanced insights into the trust development process within the PPI Ignite Network, and 3) enhance our understanding of trust in the community-based participatory research model.

Strengths and Limitations of this Study:

- This study provides empirical support for using tools and techniques from network science to clarify important conceptual and operational complexities of trust in participatory health research partnerships across two timepoints. In doing so, we help address critical ambiguities that hinder the application and evaluation of participatory health research in health promotion.

- Our approach to measuring trust in participatory partnerships embraces its multidimensional nature, allowing us to see how trust unfolds, across all its dimensions, over two timepoints.
- By exploring trust in this way, we embraced the partnership environment, which plays an important role in trust and partnership synergy and sustainability.
- This case study used a small network with two time points over a year. Considering trust takes time to develop, it is possible that surveying trust at only two time points over a year is restrictive.
- As trust is inherently contextual, its evolution will likely vary depending on the partnership of interest.

Keywords: participatory, community-based participatory research, trust, social network analysis, social networks

Patient and Public Involvement Statement

This is one sub-study that is part of a larger study in which a Research Advisory Group was involved. This group comprises four research partners representing academic, service, or community organisations in the PPI Ignite Network (further described in this manuscript). These partners were a subset of individuals interested in this work, who were already working with co-authors JS, AM and MG through a prior grant called PPI Ignite@UL. These partners provided input and approval for the research objectives of this study, ensured all content in the network surveys and interview guide were both accessible to participants and contextually relevant, reviewed and interpreted findings at a high-level confirming from their perspective, if they agreed with the findings as a partner in the PPI Ignite Network, acted as a soundboard for brainstorming ways to address any research challenges, provided suggestions/feedback for ensuring dissemination materials and outputs (e.g., conference posters and manuscripts), and were being communicated effectively for diverse audiences. One Research

Advisory Group member has been further involved in the interpretation of the results as well as reviewing and revising manuscript content and language, and thus, authorship of this manuscript (co-author MMC). Co-author MMC was also involved in the dissemination of this work at an international conference (*cf* [1])

BACKGROUND

The value of a participatory approach to the generation of evidence for health and social services from a moral, methodological and policy perspective continues to develop on a global scale [2-4]. Participatory Health Research (PHR) can be defined as "systematic inquiry, with the collaboration of those affected by the issue being studied, for the purposes of education and taking action or effecting change."[5](pg.43) In PHR, "those affected" is intentionally broad encompassing individuals, community members, or groups such as patients, public, health professionals, and organisational representatives. These individuals/groups can be both directly or indirectly affected by a health issue.[6]

With roots grounded in principles of social action, justice and emancipatory philosophy, PHR has the potential to tackle complex health problems and achieve more meaningful and nuanced short and long-term outcomes [6-8]. PHR has been gaining recognition throughout research communities as an approach that serves to bridge the gap between research and practice.[6, 8, 9] Specifically, PHR helps to maximise the relevancy of research and usability of its products, while simultaneously building capacity and addressing issues of social justice and self-determination among end-user communities.[6, 8] The central tenet of PHR is its co-creation process, where those affected by the issue under investigation or who benefit from the knowledge being produced, are key to the knowledge production process, working as equitable partners with academics from idea conceptualisation to dissemination and beyond [6, 10].

In this paper, we discuss PHR as an umbrella term for a variety of approaches (e.g., participatory action research [11], participatory rural appraisal [11, 12], community-based participatory research (CBPR)[13, 14]). While terminologies may vary by country of origin, discipline and research goals,[13, 15] they all strive to bridge the gap between knowledge and practice by harnessing inclusivity and recognising the importance of actively and meaningfully engaging those who the research serves to benefit in the research process [6].

One widely recognised approach to PHR [6, 16] is CBPR. A conceptual model for CBPR was developed[17] and later adapted [8], providing a concrete framework for understanding how the CBPR process is influenced by contextual and process-related aspects that can affect the ability to achieve both short-term impacts (e.g. stronger partnerships) and long-term outcomes (e.g. improved health, community transformation, and health equity). The intention of the model is to act as a dynamic tool that evolves with research and understanding of CBPR. This includes a deeper understanding of how context, partnership characteristics, and processes contribute to research and intervention design, and ultimately lead to intermediate and long-term outcomes [18]. However, challenges in operationalising aspects of the model limit our understanding and evaluation of the PHR process. For instance, Oetzel et al.[19, 20] noted that additional longitudinal research is required to better understand how CBPR processes lead to outcomes and under what conditions, to further substantiate the mechanisms in the model [19, 20].

Trust is frequently identified as an important component of the CBPR model, described as "permeating and affecting all interactions and relationships in the partnership and as linking one [domain] to another [21](pg.14)." Trust has been underscored as a crucial mechanism [22, 23] essential to the PHR process that can affect the ability to achieve both intermediate impacts and long-term outcomes [24, 25]. For example, seminal work by Jagosh et al.[23] found that the

building and maintenance of trust was a key mechanism for supporting partnership synergy, a universal feature of the collaborative process necessary for building and sustaining partnerships. Synergy has been described as "the power to combine the perspectives, resources and skills of a group of people and organizations (pg.183)," and influences partnership effectiveness [26]. However, defining, measuring and operationalising trust in PHR is challenging given the overwhelming variation in how it is defined [27]. This reflects sentiments expressed by Misztal et al.[28](pg.117), underscoring that of Wuthnow et al.[29], describing trust as "one of the most complex, multidimensional and misunderstood concepts in the social sciences [28, 29](pg. 117)."

As explicated by Lucero et al. [30], "although numerous CBPR scholars have discussed the importance of trust and offer anecdotal suggestions, very few systematically research it (pg. 160)." Influential work by Lucero et al.[25, 30, 31], has provided important advancements in the study of trust in participatory literature presenting, for the first time to our knowledge, an alternative to the binary view of trust in CBPR (i.e., present or absent). As highlighted above, Lucero et al.[25, 30, 31] operationalised trust a typology of six categories from the lowest type being a trust deficit (suspicion) to the highest, called critical reflexive trust (having the ability to discuss and move on after a misstep). However, more work is still needed, especially exploring trust types over time.[25] With the recognition that trust is a dynamic, socially embedded process and extends beyond a simplified view as a variable, it requires a methodology that reflects this.[22]

One approach is to view PHR partnerships as a *social network.* A social network describes the relationships among people, organisations or other social actors [32]. Social network analysis (SNA) is a methodology for describing and measuring contextual and relational dynamics among and between social entities like individuals or organisations [33]. Trust is a type of relation that has been commonly explored in the network literature in diverse fields [34-50], such as in health

[51] and education [52]. As mentioned by Zolin and Gibbons,[50] "for a researcher, analysis of networks that are directly or indirectly related to trust may yield practical and theoretical insights that are not discoverable through other means...(pg.189)". This is because, unlike other methods, SNA allows us to understand trust while embracing its social environment[50]. This is a key strength of SNA as it extends beyond the behaviour of the individual, embracing the social aspects of behaviour. Using SNA, we can consider the interdependent nature of human data.[32, 53] Further, as trust is a type of relation, it is inherently embedded in a network of relationships. This creates opportunity to explore a variety of research questions about trust [50]. For example, network questions can help us explore how trust is developed over time [50]. Indeed, viewing PHR partnerships as a social network, applying SNA tools and techniques to explore trust over time, could help address the challenges that persist in operationalising trust in the CBPR model, and in turn, improve our understanding and evaluation of trust in the PHR process.

Recognising this potential, Gilfoyle et al.[54] then proposed a novel and interdisciplinary conceptual triad in their scoping review, with trust in the centre, connecting PHR and SNA, to explore how trust can be conceptualised, operationalised and measured in PHR and social networks literature. Results from this review[54] revealed two key findings. Firstly, it found trust to be multidimensional, identifying several key trust dimensions. Secondly, it underscored a lack of conceptual and operational consistency of trust, particularly in the PHR literature. Gilfoyle et al.[55] then empirically tested the merits of exploring trust in a PHR partnership, known as the national Public and Patient Involvement (PPI) Ignite Network (see Setting below), comprehensively and in a multidimensional way. This revealed important nuances between the different dimensions of trust between partners who had national and local roles, which become diluted when explored in combination.

However, authors[55] were limited in that they explored trust cross-sectionally and without attention to specific attributes, such as partnership characteristics (e.g., local or national partners). This is problematic because trust develops over time [22, 25, 31], and networks are dynamic as their membership and social contexts change [56]. Further, network attributes, such as the roles of local or national partners, can influence collaborative behaviour [32], also warranting investigation over time. This is especially important in PHR where the importance of trust throughout all phases of the research process is underscored [21, 31], especially for ensuring partnerships are effective, equitable and long-term.[22, 25, 57, 58] Thus, if some types of partners (e.g., those who hold funding [cf [18]) are developing trust and others (e.g., either local partner or national partners) are not, important goals and ultimately outcomes of a partnership may be jeopardized. Addressing these limitations, this case study seeks to extend the findings from Gilfoyle et al.[55], better understand the evolution of trust in the context of a participatory health research partnership (see setting below). This is done by exploring specific features of a PHR network (the national PPI Ignite Network in Ireland) asking:

1. Do the trust characteristics of the PPI Ignite Network change from T1 to T2?
2. Do the dimensions of trust identified differ at the local vs the national level? How did this evolve from T1 to T2?

METHODS

This study was granted ethics approval from the University of Limerick Education and Health Sciences Research Ethics Committee (#2021_03_16_EHS).

Setting

In 2017, five universities across Ireland were funded as individual *PPI Ignite Teams* by the Irish Health Research Board (HRB) and Irish Research Council (IRC) to build capacity for PPI in health research. Building on and consolidating this work, the HRB and IRC then funded the *PPI Ignite Network* (March 2021-2026), "aim[ing] to provide a shared voice for PPI across Ireland, aiming to change the research culture, and an important contributor to improving health outcomes for the public."

The PPI Ignite Network brings together academic, service and community organisations who co-designed the work programme and must collaborate in a synergistic and cohesive manner to plan, implement and evaluate the PPI initiatives set, where trust plays a central role [22-25]. The PPI Ignite Network's work focuses on five key areas: 1) building capacity for PPI in community and academic settings, 2) develop accredited education programmes for PPI, 3) enhance university policies and procedures to support PPI, 4) develop quality improvement and impact; and 5) create systems for national co-ordination and functioning (for further information on the PPI Ignite Network see: https://ppinetwork.ie/about-us/).

The PPI Ignite Network (n=57 at T1 and n=56 at T2 at time of sampling), a national PHR partnership, provides an ideal setting to better understand how trust evolves in a PHR partnership over time. At the time of sampling, the PPI Ignite Network included seven universities (called lead sites, including the original five PPI Ignite Teams, and two additional institutions), a national office, 10 national-level community partners contributing to national-level governance and activities, and 39 (at T1) and 38 (at T2) local-level partners contributing to governance and activities at one university in the PPI Ignite Network. This administrative structure of the PPI Ignite Network resembles a hub and spokes model. The national office acts as the hub, at the center of the administrative structure, connecting with national partners and the seven universities, while

the universities are further connected to their local partners. Within this structure, resource allocation and decision-making pertaining to goals and objectives are distributed across the Network. All partners (i.e., National and Local) in the PPI Ignite Network interact through multiple avenues, including, local partner meetings (i.e., site leads and their local partners), PPI Ignite Network-wide meetings (all partners), five work packages each addressing a specific function central to the Network's goals (outlined as key work areas above) (open to all partners), and the National PPI Festival{PPI Ignite Network, #1001} (open to all partners and external participants). The PPI Ignite Network functions as a participatory partnership where we explore the dimensions of trust in action for this study.

A Research Advisory Group, consisting of four research partners from academic, service, or community organisations within the PPI Ignite Network, provided input and approval for the case study's objectives. These partners were similarly involved in three other sub-studies. Their partner contributions included: providing input and approval for the research objectives, ensuring all content in the network survey and interview guide were accessible and contextually relevant, reviewing and interpreting findings at a high-level confirming their agreement as Network partners, providing feedback to ensure dissemination materials and outputs (e.g., conference posters and manuscripts) effectively communicated findings for diverse audiences. One Research Advisory Group member contributed further by interpretating results and reviewing and revising manuscript content and language. This partner is listed as co-author MMC.

Data Collection

A social network can be defined as the set of connections among people, organisations or other social actors [32]. This study invited all 57 individuals at T1 (May 2021) and 56 individuals at T2 (May 2022), in the PPI Ignite Network, to complete the same network survey at these two timepoints. This timeframe was chosen based on discussions with the Research Advisory Group,

recognizing that the initial stages of partnership development as crucial for the trust development process [59], while also ensuring sufficient time for trust to build.

A network survey is a questionnaire designed to generate names and connections among individuals in a network [32]. The network survey in this study was developed based on the dimensions of trust identified by Gilfoyle et al.[54] and in collaboration with the Research Advisory Group to ensure its clarity and appropriateness (See Supplementary File 1 for the Network Survey). The survey was administered electronically via Qualtrics software (Version May 2021 to December 2022). Survey questions included seven network questions corresponding to the dimensions of trust identified as important in previous work [54] (shown in Table 1).

To generate each trust dimension network, all participants were asked to name up to seven organisations when responding to the network survey questions (the same seven organisations for each question), and to consider the *individual* representing each organisation in their responses. This distinction is critical as this case study is focused on trust within a collaborative partnership, not organisational trust.

The seven dimensions of trust and their corresponding network questions were informed by a scoping review by Gilfoyle et al.[54], which comprehensively synthesised how trust had been conceptualised and operationalised in both the PHR and social network literature, and if/where convergence existed. This scoping review [54], included a thematic analysis of the extracted literature, to better identify the conceptual and operational linkages of trust across and within the PHR and social network literature through their thematic groupings. The relational constructs (i.e., sub-themes from this review) along with discussions from the Research Advisory Group, informed the dimensions of trust identified. An overview of how the dimensions of trust were conceptualised

and operationalised is presented in Table 1 below, informed by [54] and also presented in previous work [55]. A subsequent study provided empirical support for the scoping review findings.[55]

Table 1: Conceptual and operational descriptions for each trust dimension (also presented in previous work [54, 55])

Dimension of Trust	Definition	Network Question
1 – Vulnerability	Describes the willingness of an actor (trustor) to be vulnerable to the actions of another actor (trustee). The trustor does not have complete control over how the trustee will behave and is thus, uncertain about how the individual will act, which also implies that there is something of importance to be lost, and in turn, risk involved. Therefore, to be vulnerable, there must be an opportunity for risk where the trustor must then decide if they are willing to take the risk of placing trust in the trustee. Furthermore, if there is the possibility of risk, this implies that there will be some level of uncertainty regarding how the trustee will behave. It is noted that if there is trust between partners, there is a lower level of uncertainty between how the trustee will behave. In summary, for this sub-theme we consider uncertainty and risk as necessary aspects of vulnerability.	"I would discuss with [name of network member X] how I honestly feel about my work, negative feelings and frustrations."
2 – Integrity	Concerns the extent to which the trustor thinks that the trustee will act in their best interest and the belief that the trustee will follow a set of principles, deemed acceptable by the trustor, such as they will say what is true.	"[name of network member X] keeps my interest in mind when making decisions."
3 - Reliability	Describes the confidence in and extent to which the trustor believes the trustee's will follow-through on commitments, perform a given task, and/or make decisions about something.	"[name of network member X] is dependable. For example, they stick to their word and makes sure their actions and behaviours are consistent."
4 - Ability	Describes an individual's (trustee) ability to perform a given task or make decisions about something based on	"I am comfortable asking [network member X] to take responsibility for project tasks even when I am

	their perceived skill set and competence from the perspective of another individual (trustor).	not present to oversee what they do."
5 - Shared values, visions and goals	Highlights the need to have shared visions, values and goals in partnerships. Specifically, common goals, missions, and plans can promote trust.	"I feel that [network member X] shares a vision with PPI Ignite Networks vision and goals?"
6 - Power sharing and co-ownership	Sharing power and fostering co-ownership in partnerships as a dimension of trust.	"I feel that [network member X] is open to discussion* about matters pertaining to the PPI Ignite Network." *Note: When we say open to discussion, we mean that this individual is willing to engage in frank, open and civil discussion (especially when disagreement exists). The person is willing to consider a variety of viewpoints and talk together (rather than at each other) and you are able to communicate with this individual in an open, trusting manner.
7 - Reciprocity	This sub-theme describes the presence of trust based on the notion that they think the trustee also trusts them back. Thus, if a trustor thinks that the trustee also trusts them, trust is thought (by the trustor) to be reciprocated (by the trustee).	"I feel that [network member X] trusts me."

Analysis

Individual networks for each dimension of trust were constructed from participant responses to the seven trust statements included in the network survey at both timepoints. Responses were quantified by assigning edge (i.e., connection between two individuals) weights from –1 to +1, based on a 5-point scale (strongly disagree to strongly agree), with intervals of 0.5. For example, a response of 'agree', was assigned a weight of 0.5, while 'strongly agree' received an edge weight of 1. Conversely, responses of 'neither agree nor disagree', 'disagree', or 'strongly disagree' did not result in an edge (i.e., connection in the network). This is because, in alignment with the literature on trust, we did not want to infer neutral agreement or disagreement with each

statement as an expression of *distrust*. Distrust is said to differ conceptually from trust [60] and more specifically stated by Jones (1996) "the absence of trust is not to be equated with distrust [61]." Thus, by focusing explicitly on trust connections that were present, we avoid misinterpretation of neutral and negative responses,

Network Measures

Several network measures were used to analyse each of the seven trust dimensions at both T1 and T2. Specifically:

- *In-degree measures* the number of incident edges an individual in the PPI Ignite Network has, i.e., the number of times a person in the network was nominated by another individual in the network. This metric helped identify trust relationships between individuals (i.e., who trusts whom).
- *Weighted in-degree* represents the total strength of agreement for each trust statement (described further in the analysis).
- *Average in-degree, as* reported in this paper, reflects the mean number of received nominations across the network, providing insight into the overall level of trust in the network. Additionally, *average in-degree* allowed us to assess changes in the number of incoming edges received in the network as a whole (i.e., agreement or strong agreement for a specific dimension of trust) over time.
- *Clustering coefficient* measures the extent to which individuals cluster together in the PPI Ignite Network, specifically examining the proportion of closed triads (i.e., triangles) in the network [62]. For example, if there are three individuals in a network, A, B, and C and individuals A and B trust each other, and B and C trust each other, then, if this is a closed

triad, A and C will also trust each other. The clustering coefficient tells us how frequently this occurs. This identifies how trust is shared within groups throughout the network.

- *Reciprocity* at the network level measures the proportion of reciprocated edges in the network [62]. A reciprocated edge occurs when trust is mutual (e.g., both individuals agree or strongly agree on the same trust dimension). The concept of reciprocity is often recognized as a critical mechanism of trust [46, 57].
- *Freeman Centralisation about the in-degree* measures the positional importance (centrality) of individuals in the trust dimension network [63]. A higher value for one (or a small number of) individual(s), suggests that they hold a position of influence for a specific trust dimension. Conversely, a *decentralised* indicated that influence is distributed across many individuals.

These measures allowed us to compare the structural properties of trust dimensions.

Additionally. a separate network was constructed to include only the connections present at both timepoints. This provided a basis to compare changes in average in-degree and centralisation about the in-degree for individuals who consistently selected the same people at both timepoints (i.e., individuals whose rate of agreement remained stable over time). This enabled us to examine how trust evolved over time for those naming new individuals in T2 (e.g., due to staff turnover, new partnerships, or interactions driven by work package preference), compared to those who maintained their nominations from T1.

Analysis of trust over two timepoints

To compare trust networks across T1 and T2, we only included responses from individuals that participated in both timepoints. First, we performed a two-sample Kolmogorov-Smirnov (KS) test on the degree distributions. The KS-test, a non-parametric test for comparing two probability

distributions, calculates the maximal difference between the cumulative forms of the two distributions. This provides a measure of the differences between the distributions, allowing us to assess the extent to which trust dimension networks differ over time. While degree distribution analysis reveals the nature of connections in the networks, it does not provide insights into specific patterns, such as who is connected to whom, or whether participants with a low in-degree tend to connect with others of a low in-degree or those with a high in-degree.

To further examine differences, we calculated the Hamming-Ipsen-Mikhailov (HIM) distance. This metric combines the Hamming distance [64, 65], which measures the number of matching edges between two networks (i.e., trust dimensions at T1 and T2), with the Ipsen-Mikhailov distance, a 'spectral distance,' used to assess differences in the overall network structure [66]. Spectral distances are useful for assessing global structural differences but may overlook variations in smaller sub-structures. The HIM distance [67] ranges from 0 to 1, where a score of 0 indicated identical networks, and 1 indicates opposite networks. For example, a complete graph (a network where everyone is connected to everyone else) compared to a graph with no edges would yield an HIM distance of 1.

Local vs National Partners

To determine whether trust dimension networks differed between local and national partners, we stratified each trust dimension network accordingly by type (i.e., local or national). Due to the small sample size and given their role in governing the national network, we combined the national office (n=1) and lead sites (n=7) with the national partners (n=10) into a single overarching *national* category. We then calculated the network measures described above at both T1 and T2, to examine changes in the trust dimension networks over time for each local and national partner.

RESULTS

In T1 (May 2021), 57 individuals from the PPI Ignite Network were invited to complete the network survey, with 43 participants (75%) responding. By T2 (May 2022), one organisation had left the network, reducing the total number of invitees to 56. Of these 56 individuals, 33 individuals (59%) participated in the T2 survey. A detailed breakdown of participation by partnership type is provided in **Table 2**.

Table 2: Response rate by partner type

	Time 1 - May 2021 (n=43)		**Time 2 - May 2022 (n=33)**	
Partnership Type	Count	Participation rate by partnership type	Count	Participation rate by partnership type
Site leads*	8	100%	7	88%
National partners*	8	80%	7	70%
Local partners	27	69%	19	50%

**Combined site leads and national partners for local vs. national analysis*

Table 3 below presents the network-level measures calculated at T1 and T2 for the seven trust dimensions, including new collaborations. Over time, the number of connections (those who agree or strongly agree with that trust dimension) and the average in-degree (the number of incoming edges) decreased. On average, participants received approximately one fewer incoming connection compared to T1. This indicates that individuals were agreeing and strongly agreeing slightly *less* often on trust statements at T2.

The mean clustering coefficient, which measures the number of trust triangles, also declined over time. Similarly, the number of reciprocal edges (where trust is mutual between two individuals) decreased at T2. For in-degree centralisation, there was a slight *increase* for most trust dimensions, except for trust dimension 5 (shared values, visions, and goals) and trust

dimension 7 (reciprocity). This suggests that over time, incoming trust connections became slightly more concentrated among an individual/group of individuals. Despite this subtle increase, the networks remained relatively decentralised at both timepoints.

In general, the magnitude of change in each network measure varied depending on the trust dimension. For instance, trust dimension 6 (power sharing and co-ownership) consistently reported one of the highest total number of connections (i.e., the trust statement most likely to receive agreement or strong agreement) at both timepoints. However, trust dimension 6 also had the greatest decrease in connections over time, indicating the largest decline in agreement compared to other trust dimensions. In contrast, trust dimension 2 (integrity), had one of the lowest numbers of connections at both timepoints, reflecting fewer individuals agreeing or strongly agreeing with the integrity statement. Additionally, trust dimension 2 exhibited the smallest change in connections over time, suggesting relative stability across timepoints. For other network measures, such as mean clustering coefficient (i.e., average number of trusted groups), there was no change from T1 to T2 for trust dimension 4 (ability). However, a relatively large reduction was observed for trust dimension 5 (shared values, visions, and goals) over time.

Network measures also revealed that certain trust dimension networks exhibited similarities. For example, trust dimension 1 (vulnerability) and trust dimension 2 (integrity), showed comparable network measures, as did trust dimension 5 (shared values, visions, and goals) and trust dimension 6 (power-sharing and co-ownership). However, while dimensions 1 (vulnerability) and 2 (integrity) were similar to each other, they were notably different from dimensions 5 (shared values, visions, and goals) and 6 (power-sharing and co-ownership). This finding was consistent over time.

Table 3: Network-level measures over time*

Networks	Number of Edges±	Weighted In-degree Mean (std) ±	Clustering Coefficient Mean (std) ±	Weighted In-degree Centralisation±	Reciprocity±
Trust Dimension 1[a] (Vulnerability)	66 **50**	1.98 (3.00) **1.33 (2.29)**	0.10 (0.20) **0.04 (0.11)**	0.23 **0.25**	0.28 **0.06**
Trust Dimension 2[b] (Integrity)	64 **53**	1.78 (2.84) **1.54 (2.55)**	0.11 (0.23) **0.04 (0.11)**	0.24 **0.29**	0.34 **0.19**
Trust Dimension 3[c] (Reliability)	103 **86**	3.61 (4.40) **2.70 (4.09)**	0.13 (0.20) **0.11 (0.18)**	0.33 **0.34**	0.37 **0.19**
Trust Dimension 4[d] (Ability)	83 **59**	2.65 (3.92) **1.76 (2.72)**	0.06 (0.12) **0.06 (0.14)**	0.26 **0.27**	0.29 **0.24**
Trust Dimension 5[e] (Shared values, visions, and goals)	130 **98**	4.17 (5.68) **3.39 (4.80)**	0.20 (0.25) **0.13 (0.21)**	0.41 **0.38**	0.45 **0.18**
Trust Dimension 6[f] (Power sharing and co-ownership)	126 **90**	3.91 (5.04) **3.09 (4.53)**	0.16 (0.21) **0.10 (0.17)**	0.35 **0.37**	0.43 **0.20**
Trust Dimension 7[g] (Reciprocity)	102 **75**	2.91 (3.92) **2.26 (3.15)**	0.15 (0.24) **0.11 (0.21)**	0.28 **0.23**	0.41 **0.21**

**This table includes all connections including new collaborations at time.* ±Non-bolded values are T1, and bolded values are T2. [2a]*Trust Network 1 question "I would discuss with [name of network member X] how I honestly feel about my work, negative feelings and frustrations",* [b]*Trust Network 2 question "[name of network member X] keeps my interest in mind when making decisions",* [c]*Trust Network question: "[name of network member X] is dependable. For example, they stick to their word and makes sure their actions and behaviours are consistent,* [d]*Trust Network 4 question:"I am comfortable asking [network member X] to take responsibility for project tasks even when I am not present to oversee what they do",* [e]*Trust Network 5 question:"I feel that [network member X] shares a vision with PPI Ignite Networks vision and goals?",* [f]*Trust Network 6 question:"I feel that [network member X] is open to discussion* about matters pertaining to the PPI Ignite Network",* [g]*Trust Network 7 question: "I feel that [network member X] trusts me"*

Kolmogorov-Smirnov (KS) test

After calculating the KS statistic, a non-parametric test for comparing two probability distributions, we did not find a statistically significant difference in the in-degree distribution

across any of the trust dimensions from T1 to T2. This suggests that the two samples were drawn from the same distribution. Such consistency aligns with expectations, as participants ideally name others in a similar way across timepoints, rather than thoughtfully at T1 and randomly at T2.

However, the KS statistic revealed some variation among the trust dimension networks over time. For instance, trust dimensions 3 (reliability) and 6 (power sharing and co-ownership), showed the largest KS statistic (0.20), indicating relatively greater changes over time, while trust dimension 2 (integrity) had the smallest KS statistic (0.09), suggesting minimal change. Although these changes in KS statistic were subtle overall, the variation highlighted differences across the trust dimensions and how they evolved from T1 to T2. For plots see Supplementary File 2.

Hamming and Ipsen-Mikhailov (HIM) distance

As our networks had a low density of connections, we recognized that HIM distance, exploring whether connections between individuals change over time, would never be close to one. Therefore, we focused less on the overall magnitude of the HIM distance value and, more on the relative differences across trust dimensions. We observed a small range in HIM distance across the dimensions of trust, ranging from 0.08 – 0.12. Specifically, networks for trust dimension 2 (integrity) (HIM = 0.08) were more similar from T1 to T2 compared to trust dimension 5 (shared values visions and goals) (HIM = 0.12). See Supplementary File 3 for further details.

Indeed, both the KS statistic and HIM distance revealed greater differences across trust dimensions than within each dimension from T1 to T2.

Local vs National Comparison

Findings for the weighted mean in-degree and clustering coefficient by type of node (local vs national) T1 and T2, are presented in **Table 4** below. We observed a decrease in the weighted mean in-degree (i.e., average number of incoming connections) for both local and national partners

across trust dimensions over time. However, the weighted mean in-degree was higher for national partners than the local partners at both time points, across all trust dimensions. This suggests that individuals who were national partners or site leads in the PPI Ignite Network, received more trust nominations (i.e., more people agreeing or strongly agreeing with trust statements about them) compared to local partners. We noted the largest difference between local and national partners in trust dimension 5 (shared values, visions, and goals) at both T1 and T2, while trust dimension 2 (integrity) showed the smallest difference between these groups over the same periods. In contrast, the clustering coefficient did not show consistent trends across partnership type. For example, at T1, some local partners exhibited a higher clustering coefficient (i.e., more trust triangles) compared to national partners. However, by T2, these trends reversed, with local partners having a lower clustering coefficient for certain trust dimensions. This was evident in trust dimensions 5 (shared values, visions, and goals), 6 (power sharing and co-ownership), and 7 (reciprocity).

Table 4: Network Measures for Trust Dimensions at T1 and T2 stratified by Local vs National Node Type

	Node Type (Local [n=27] and National [n=15])	**Weighted In-degree Mean (std)**		**Clustering Coefficient**	
		Time 1	**Time 2**	**Time 1**	**Time 2**
Trust Dimension 1[a] (Vulnerability)	*Local Nodes*	0.55 (0.94)	**0.27 (0.54)**	0.11 (0.23)	**0.07 (0.16)**
	National Nodes	4.40 (4.06)	**3.27 (3.11)**	0.11 (0.16)	**0.03 (0.05)**
Trust Dimension 2[b] (Integrity)	*Local Nodes*	0.59 (0.94)	**0.36 (0.64)**	0.11 (0.23)	**0.03 (0.11)**
	National Nodes	4.00 (3.95)	**3.80 (3.37)**	0.13 (0.26)	**0.08 (0.13)**
Trust Dimension 3[c] (Reliability)	*Local Nodes*	1.50 (1.31)	**0.77 (1.00)**	0.16 (0.25)	**0.10 (0.21)**
	National Nodes	7.20 (5.96)	**6.60 (5.17)**	0.11 (0.13)	**0.18 (0.16)**
Trust Dimension 4[d] (Ability)	*Local Nodes*	0.63 (0.87)	**0.45 (0.72)**	0.04 (0.11)	**0.01 (0.05)**
	National Nodes	6.20 (5.44)	**4.33 (3.42)**	0.09 (0.08)	**0.17 (0.20)**
	Local Nodes	1.50 (1.34)	**1.18 (1.53)**	0.27 (0.30)	**0.15 (0.27)**

Trust Dimension 5[e] (Shared values, visions and goals)	*National Nodes*	9.20 (7.58)	**7.93 (6.02)**	0.17 (0.17)	**0.17 (0.14)**
Trust Dimension 6[f] (Power sharing and co-ownership)	*Local Nodes*	1.63 (1.33)	**1.00 (1.31)**	0.20 (0.25)	**0.08 (0.20)**
	National Nodes	8.20 (6.82)	**7.40 (5.69)**	0.15 (0.15)	**0.16 (0.14)**
Trust Dimension 7[g] (Reciprocity)	*Local Nodes*	1.18 (1.11)	**0.81 (1.11)**	0.19 (0.27)	**0.12 (0.27)**
	National Nodes	6.20 (5.29)	**5.27 (3.86)**	0.16 (0.25)	**0.16 (0.16)**

[a]*Trust Network 1 question"I would discuss with [name of network member X] how I honestly feel about my work, negative feelings and frustrations",* [b]*Trust Network 2 question"[name of network member X] keeps my interest in mind when making decisions",* [c]*Trust Network question: "[name of network member X] is dependable. For example, they stick to their word and makes sure their actions and behaviours are consistent,* [d]*Trust Network 4 question:"I am comfortable asking [network member X] to take responsibility for project tasks even when I am not present to oversee what they do",* [e]*Trust Network 5 question:"I feel that [network member X] shares a vision with PPI Ignite Networks vision and goals?",* [f]*Trust Network 6 question:"I feel that [network member X] is open to discussion* about matters pertaining to the PPI Ignite Network",* [g]*Trust Network 7 question: "I feel that [network member X] trusts me"*

Figures 1 and 2 illustrate the networks for these two trust dimensions over time. The networks appeared less dense for trust dimension 2 (integrity) over time (Figure 1), while they became denser for trust dimension 5 (shared values, visions, and goals) (Figure2). This indicates that rate of agreement differed across these trust dimensions, highlighting an important nuance detected when examined as distinct networks. Additionally, we observed that more partners were disconnected from the networks in T2 compared to T1 for both dimensions of trust. This is particularly pronounced for Trust Dimension 2 (integrity). The disconnection of partners suggests that trust connections for these partners no longer existed at T2 for the respective trust dimension.

Figure 1: Trust Dimension 2 – Integrity - at T1 and T2

[insert here]

Figure 2: Trust Dimension 5 – Shared Values, Visions and Goals at T1 and T2
[insert here]

Persistent Connections in T1 and T2

Findings comparing network measures of persistent connections (i.e., the same person nominated in both T1 and T2) are outlined in Table 5[1] below. In this analysis, individuals who formed new collaborations and nominated new individuals in T2, were excluded. This approach allowed us to focus specifically on trust connections persisted over time. Interestingly, the average number of weighted incoming connections across all trust dimensions increased from T1 to T2. This suggests that, for individuals who were nominated consistently across T1 and T2, the level of agreement regarding trust statements increased.

Table 5: Network-level measures over time*

Networks (n=59)	**Weighted In-degree Mean (std)**		**Weighted In-degree Centralisation**	
	T1	***T2***	***T1***	***T2***
Trust Dimension 1[a] (Vulnerability)	0.85 (1.74)	**1.02 (1.88)**	0.17	**0.16**
Trust Dimension 2[b] (Integrity)	0.83 (1.89)	**1.09 (2.10)**	0.17	**0.18**
Trust Dimension 3[c] (Reliability)	1.57 (2.64)	**1.89 (3.01)**	0.22	**0.24**
Trust Dimension 4[d] (Ability)	1.09 (2.04)	**1.37 (2.34)**	0.21	**0.20**
Trust Dimension 5[e] (Shared values, visions, and goals)	2.02 (3.02)	**2.37 (3.60)**	0.23	**0.29**
Trust Dimension 6[f] (Power sharing and co-ownership)	1.98 (3.00)	**2.30 (3.59)**	0.23	**0.30**

[1] Non-weighted properties such as clustering coefficient and reciprocity are not included as they would not change over time as we are only including persistent connections.

Trust Dimension 7[g] (Reciprocity)	1.26 (2.29)	**1.67 (2.65)**	0.18	**0.19**

**This table explores connections that were persistent over time (i.e., excludes new collaborations in T2).* [a]*Trust Network 1 question "I would discuss with [name of network member X] how I honestly feel about my work, negative feelings and frustrations",* [b]*Trust Network 2 question "[name of network member X] keeps my interest in mind when making decisions",* [c]*Trust Network question: "[name of network member X] is dependable. For example, they stick to their word and makes sure their actions and behaviours are consistent,* [d]*Trust Network 4 question:"I am comfortable asking [network member X] to take responsibility for project tasks even when I am not present to oversee what they do",* [e]*Trust Network 5 question:"I feel that [network member X] shares a vision with PPI Ignite Networks vision and goals?",* [f]*Trust Network 6 question:"I feel that [network member X] is open to discussion* about matters pertaining to the PPI Ignite Network",* [g]*Trust Network 7 question: "I feel that [network member X] trusts me"*

In summary, findings highlighted:

- An SNA approach revealed subtle changes over time in when exploring trust multidimensionally in the PPI Ignite Network. On average there was a slight decrease in trust connections across each trust dimension from T1 to T2 on a global level. This indicates that, at the second time point, fewer individuals agreed or strongly agreed with a given trust statement about the individual they nominated in the network compared to the first timepoint. However, trust connections that remained consistent over time, showed an increase across all dimensions of trust.
- More distinct differences emerged when stratifying trust by partnership type (i.e., local or national partners). National partners and site leads in the PPI Ignite Network received more trust nominations, meaning more people agreed or strongly agreed with trust statements about them, compared to local partners.

DISCUSSION

This case study extends the work by Gilfoyle et al., [54, 55] by comparing the dimensions of trust across two timepoints, stratified by local or national partnership types, and more broadly, by contributing to the conceptual and operational gaps related to trust in participatory research

partnerships [54, 55]. By analysing the different dimensions of trust as separate networks, we identified changes across these timepoints and provided empirical support for a comprehensive, multidimensional exploration of trust as it evolved within the PPI Ignite Network.

Our analysis revealed a general decrease in the number of trust connections across most trust dimensions over the two timepoints at the network level. However, trust connections that were consistent from T1 to T2 showed increases across all trust dimensions, suggesting that when partnerships were maintained from T1 to T2, trust increased. Comparatively, the slight overall decrease in trust across the PPI Ignite Network may reflect the formation of new collaborations (e.g., new employees or partners given staff and partnership turnover and/or interacting with new people depending on their work package), where trust had not yet been established/sustained. This aligns with existing literature, which emphasizes that trust must be built and sustained over time, while new collaborations or changes in personnel can impact its development and maintenance [22, 68].

We also observed that some trust dimensions were more similar both visually (e.g., network maps) and across network measures (based on the KS-test and HIM distances), such as vulnerability and integrity. Others were markedly different, like integrity and shared values, visions, and goals with a higher number of incoming connections for national partners compared to local partners. These findings contribute meaningfully to the literature by providing empirical support for using SNA to operationalise trust in a comprehensive, context-sensitive, and multidimensional way over time. This approach avoids treating trust as a composite measure, which can overlook the unique influence of individuals trust dimensions in a PHR partnership. This distinction is critical as PHR emphasizes the need for contextually derived and driven knowledge production, to address the needs of the communities [8, 69], as highlighted in the CBPR

conceptual model [18]. Operational techniques must, therefore, consider the partnership context so that partners can both understand and evaluate if their goals are being met and if they are on a trajectory toward success. A lack of contextual consideration is a limitation of traditional quantitative methods [70], yet a strength of SNA. By incorporating both individual and system-level perspectives , SNA captures complex social-relational processes, like trust, while accounting for the social context and its influence on individuals within it [71].

Using SNA provided valuable "insight[s] into the relationships, positions, structure and strength of [the] network [72](pg.4)" across two timepoints. Through network maps, we observed where trust connections existed or were absent in the PPI Ignite Network over time, while also gaining an understanding of the implications of individual positions and the overall network structure. For example, central actors - individuals occupying highly connected positions within the network - are often viewed as opinion leader with prestige and influence [32]. These actors play a critical role in the diffusion of ideas and behaviour [32], which has important implications for the trust-building process. By equipping the PPI Ignite Network members with a better understanding of their network structure, SNA can guide strategic interventions (i.e., strategic actions that or remove links between social entities [73]) within the trust dimension networks to ensure trust is built and maintained throughout the next five years of working together and beyond.

For instance, partners can identify areas of weakness in the trust dimension networks, such as areas of fewer connections or individuals positioned on the periphery of the network, and take deliberate action to strengthen these areas. This could include fostering strategic collaboration opportunities, between central individuals (thought to have higher influence) and peripheral individuals (who have fewer connections in a given network).

Equipping partners with an enhanced understanding of the trust development process within their specific context, could in turn dictate the strategic allocation of (often limited) time and resources to enhance trust and, ultimately, partnership functioning. For instance, given the finding that local partners were less central compared to national partners (i.e., had fewer collaborations and incoming connections across trust dimensions), immediate interventions could include creating opportunities for local partners to have more influence within the PPI Ignite Network. This might involve offering local partners leadership roles in key initiatives or work packages. If partnership capacity is an issue, interventions could focus on the (re)distribution of resources and providing more targeted supports for local partners. Indeed, conceptualising and operationalising trust in this manner also helps to address a significant gap in the PHR literature. As noted, "the majority of trust and community-based participatory research literature conceptualised trust as an outcome and acknowledges that research on trust development is lacking [30](pg.62)."

Limitations

Although embracing context is important, readers should consider this when interpreting and/or applying findings to their own research. This case study examines a small network with two timepoints over a year. Considering that trust takes time to develop, surveying trust at only two timepoints may be restrictive. Additionally, not all partners in the PPI Ignite Network participated, and some who did participate did not complete both network surveys. To facilitate comparisons across timepoints, those who did not complete both network surveys were excluded, resulting in a smaller sample size. As such, the views reflected in case study might not be representative of the entire PPI Ignite Network and should be interpreted accordingly. However, consistent with findings from previous work[55], network properties differed only at the second decimal place,

suggesting that the smaller sample size likely had a minimal impact on the results. Furthermore, as trust is inherently contextual, its evolution will likely vary depending on the partnership of interest. This variability should be considered when applying these findings to other settings. Finally, while this case study employed a novel approach to operationalising trust across different contexts, it does not reveal why the networks evolved as they did. This limitation is addressed in a follow-up study published elsewhere (see [74]).

Future Research

Areas of future work could investigate if the conceptualisation and operationalisation of trust within the PPI Ignite Network led to improved partnership outcomes. For instance, 'readiness' for public and patient involvement at a national level and within individual institutions was a priority outcome of the Network. Future studies could examine whether changes in trust networks are associated with achieving the PPI Ignite Network's objective of building capacity for PPI readiness. Additionally, future research could explore whether certain trust dimensions (among the 7 identified) are particularly relevant to certain aspects of the CBPR model[8, 17]. For example, the CBPR model emphasizes power dynamics as a critical factor influencing both context and partnership processes.[75] With our enhanced understanding of trust - particularly the trust dimension 'power-sharing and co-ownership' - it may be possible to identify where power dynamics exist by pinpointing asymmetrical trust relationships within this trust dimension network. Finally, as this is a case study exploring trust in one context, future work could expand to explore the trust development process across other PHR partnerships to compare findings across multiple study contexts.

CONCLUSION

This case study employs a novel and interdisciplinary lens, integrating insights from both the social network and PHR literature, to further clarify important conceptual and operational complexities of trust. By extending the findings of Gilfoyle et al.[54, 55], we consistently and comprehensively analysed trust *over time* in a real-world partnership, the PPI Ignite Network. The findings provide empirical support for using SNA to examine the evolution of trust as a multidimensional concept in PHR partnerships over time. Future research could consider exploring trust over more extended periods, to gain deeper insights into its development and sustainability in different contexts.

AUTHOR CONTRIBUTIONS

All authors have made substantive intellectual contributions to the development of this study. MG conceptualized and led the study, drafted, and edited the final manuscript. MG is responsible for the overall content as guarantor. PMC analysed the data and contributed to the study design, data analysis and interpretation, writing, and editing of the manuscript. JS secured funding, contributed to the study conceptualisation, data analysis and interpretation, and contributed to the writing and editing of the final manuscript. AMF contributed to the study conceptualisation, writing, and editing of the final manuscript. MMC contributed to study conceptualisation, interpretation of results, reviewed and approved manuscript. ChatGPT4o was used only in the revision stages of this manuscript to help with grammar and sentence structure, like removing redundant language, suggesting word synonyms to reduce repetitiveness, and suggestions to reduce long sentences into shorter, more digestible sentences. All authors verified and reviewed final content.

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COMPETING INTERESTS

None declared.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author, JS, upon reasonable request.

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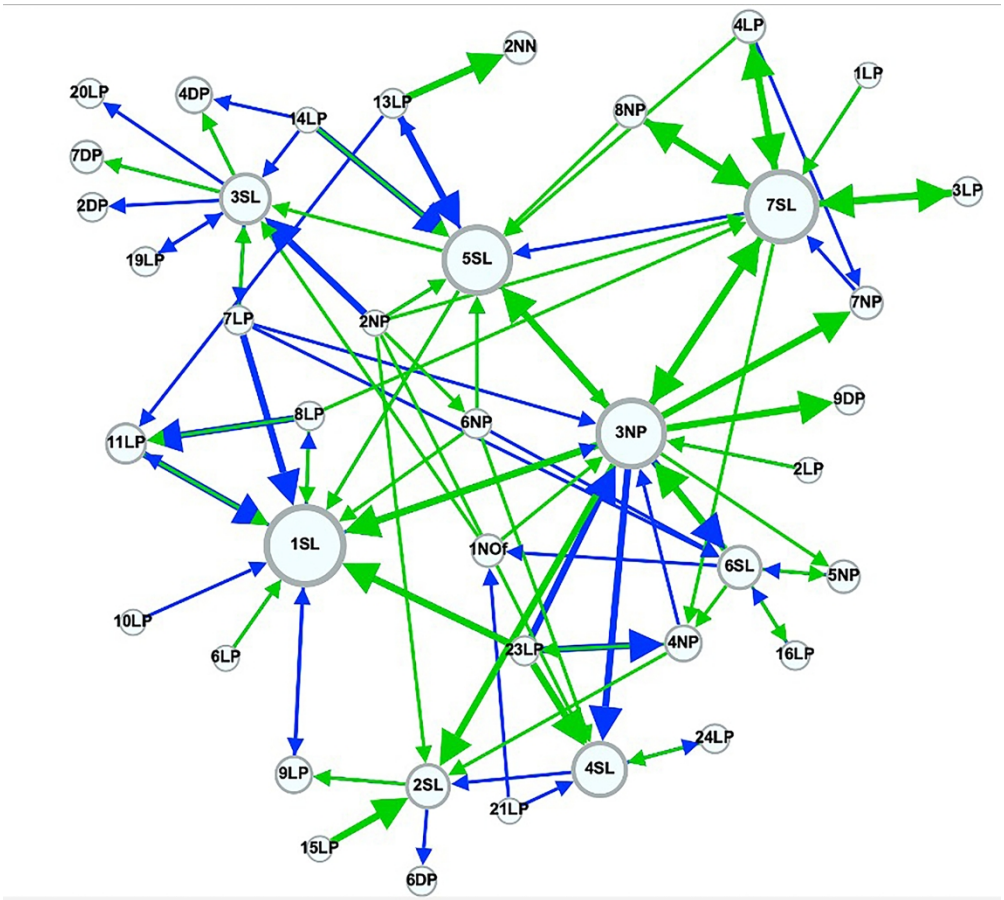
List of Figure(s):

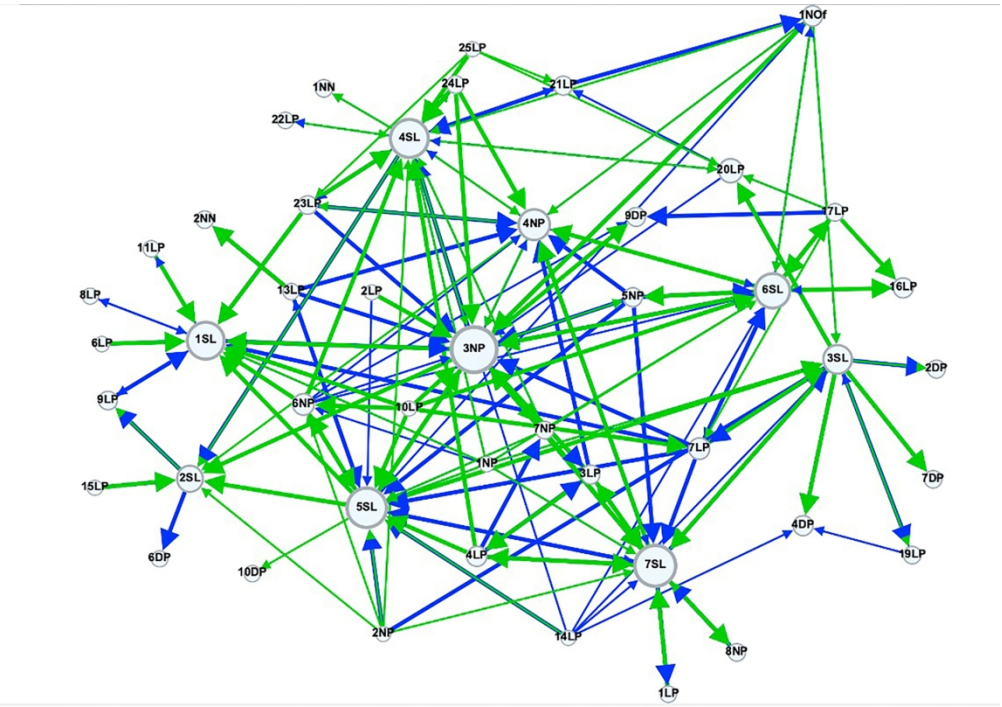
Figure 1: Trust Dimension 2 – Integrity - at T1 and T2

Figure 2: Trust Dimension 5 – Shared Values, Visions and Goals at T1 and T2



Note: Blue arrows indicate T1 connections. Green arrows indicate T2 connections. The size of the node pertains to the number of incoming nominations for that individual. A larger node has more people 'agreeing' or 'strongly agreeing' with that statement of trust about them. NP = National Partner; LP = Local Partner; SL = Site Lead; DP = nominated but did not participate in network survey; NN = nominated but not in the PPI Ignite Network.

170x152mm (300 x 300 DPI)



Note: Blue arrows indicate T1 connections. Green arrows indicate T2 connections. The size of the node pertains to the number of incoming nominations for that individual. A larger node has more people 'agreeing' or 'strongly agreeing' with that statement of trust about them. NP = National Partner; LP = Local Partner; SL = Site Lead; DP = nominated but did not participate in network survey; NN = nominated but not in the PPI Ignite Network.

169x119mm (300 x 300 DPI)

(Time 1) Network Survey and Framing Questions - PPI Network

Start of Block: Information sheet and consent form

Information Sheet **Before continuing, please review the information sheet for volunteers by clicking the link below:**

LINK: [removed for peer review]

[consent form removed for peer review]

Consent By clicking 'Yes' below, I am providing my consent to participate as indicated above OR click 'No' below, if you choose not to participate at this time.

- ○ **Yes, I consent to participate** (1)
- ○ **No, I choose not to participate at this time** (2)

End of Block: Information sheet and consent form

Start of Block: Network Questions Part 1

JS

Question 1

Thank you for taking part in this study!

You have read the study information letter and have signed an informed consent form, so you understand the purpose of the study and the use to which its findings will be put.

Individuals and institutions will be anonymised in all wider reporting of results.

This questionnaire should take approximately 15 minutes to complete.

Section 1: Network Questions

Level of Collaboration

For the following questions we are asking you to name organisations you are collaborating with on the PPI Ignite Network. When choosing an organisation, think about the specific individuals that represent the organisation in the network. *For example, if you were collaborating with [example name].*

Once you start typing an organisation's **full** name, an auto fill drop-down box will appear. Select the organisation you want. If needed, click here for a full list of network organisations.

Question 1:

a. Enter up to 7 organisations that you collaborate with on the PPI Ignite Network.

b. Beside each of the selected organisations, rank your intensity of collaboration.

(Please refer to Table A to guide your ranking)

Table A

Level **Definition** **(0) No interaction** No interaction, not aware of individual in this organisation

(1) Networking I am aware of the individual(s), but we have loosely defined roles, little communication, and all decisions made independently

(2) Cooperation We provide information to each other, have somewhat defined roles, formal communication, but all decisions are made independently

(3) Coordination We share information and resources, have defined roles, frequent communication, some shared decision making

(4) Coalition We share ideas and resources, have frequent and prioritised communication, and have a vote in each other's decision making

(5) Collaboration We belong to one system, our frequent communication is characterized by mutual trust, consensus is reached on all decisions

	0 No Interaction (1)	**1 Networking** (2)	**2 Cooperation** (3)	**3 Coordination** (4)	**4 Coalition** (5)	**5 Collaboration** (6)
Type organization 1 here: (1)	○	○	○	○	○	○
Type organization 2 here: (2)	○	○	○	○	○	○
Type organization 3 here: (3)	○	○	○	○	○	○
Type organization 4 here: (4)	○	○	○	○	○	○
Type organization 5 here: (5)	○	○	○	○	○	○
Type organization 6 here: (6)	○	○	○	○	○	○
Type organization 7 here: (7)	○	○	○	○	○	○

End of Block: Network Questions Part 1

Start of Block: Network Questions Part 2

Statement 1 **Relational questions about 7 PPI Ignite Network Members** For each of the organisation names (up to 7) you listed in Question 1, please answer the following:

Question 2: On a scale from (1) strongly disagree to (5) strongly agree, please rate the extent to which you agree with the following 7 statements:

**Note: statement 6 has additional descriptions to help guide your selection*

	1 Strongly Disagree (1)	**2 Disagree** (2)	**3 Neither agree nor disagree** (3)	**4 Agree** (4)	**5 Strongly agree** (5)
${Question 1/ChoiceTextEntryValue/1} (1)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/2} (2)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/3} (3)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/4} (4)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/5} (5)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/6} (6)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/7} (7)	○	○	○	○	○

Statement 5 .

	1 Strongly Disagree (1)	**2 Disagree** (2)	**3 Neither agree nor disagree** (3)	**4 Agree** (4)	**5 Strongly agree** (5)
${Question 1/ChoiceTextEntryValue/1} (1)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/2} (2)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/3} (3)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/4} (4)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/5} (5)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/6} (6)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/7} (7)	○	○	○	○	○

Statement 6 .

	1 Strongly Disagree (1)	2 Disagree (2)	3 Neither agree nor disagree (3)	4 Agree (4)	5 Strongly agree (5)
${Question 1/ChoiceTextEntryValue/1} (1)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/2} (2)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/3} (3)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/4} (4)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/5} (5)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/6} (6)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/7} (7)	○	○	○	○	○

Statement 7 .

	1 Strongly Disagree (1)	2 Disagree (2)	3 Neither agree nor disagree (3)	4 Agree (4)	5 Strongly agree (5)
${Question 1/ChoiceTextEntryValue/1} (1)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/2} (2)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/3} (3)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/4} (4)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/5} (5)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/6} (6)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/7} (7)	○	○	○	○	○

Statement 8 .

	1 Strongly Disagree (1)	2 Disagree (2)	3 Neither agree nor disagree (3)	4 Agree (4)	5 Strongly agree (5)
${Question 1/ChoiceTextEntryValue/1} (1)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/2} (2)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/3} (3)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/4} (4)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/5} (5)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/6} (6)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/7} (7)	○	○	○	○	○

Statement 9 .

	1 Strongly Disagree (1)	2 Disagree (2)	3 Neither agree nor disagree (3)	4 Agree (4)	5 Strongly agree (5)
${Question 1/ChoiceTextEntryValue/1} (1)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/2} (2)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/3} (3)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/4} (4)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/5} (5)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/6} (6)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/7} (7)	○	○	○	○	○

Statement 10

	1 Strongly Disagree (1)	2 Disagree (2)	3 Neither agree nor disagree (3)	4 Agree (4)	5 Strongly agree (5)
${Question 1/ChoiceTextEntryValue/1} (1)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/2} (2)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/3} (3)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/4} (4)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/5} (5)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/6} (6)	○	○	○	○	○
${Question 1/ChoiceTextEntryValue/7} (7)	○	○	○	○	○

End of Block: Network Questions Part 2

Start of Block: Framing Questions

Trust typology **Section 2 – Framing Questions**

Trust typology In this Question, we are interested in learning your views on **the type of trust** you think exists in the PPI Ignite Network at this point in time. The six trust types and their associated definition **are listed below. Question 3: Please indicate your views on trust in the PPI Ignite Network at this time. Specifically, what type of trust do you think currently exists in the network?**

CLICK ONE OF THE FOLLOWING:

- **Critical reflexive trust** (Trust that allows for mistakes and where differences can be talked about and resolved) (1)
- **Proxy trust** (Partners are trusted because someone trusted invited them) (2)
- **Functional trust** (Partners are working together for a specific purpose and time-frame, but trust may still be present) (3)
- **Neutral trust** (Partners are still getting to know each other there is neither trust nor mistrust) (4)
- **Unearned trust** (Trust is based on member's title or role with limited or no direct interaction) (5)
- **Trust deficit (suspicion or mistrust)** (Partnership members do not trust each other) (6)

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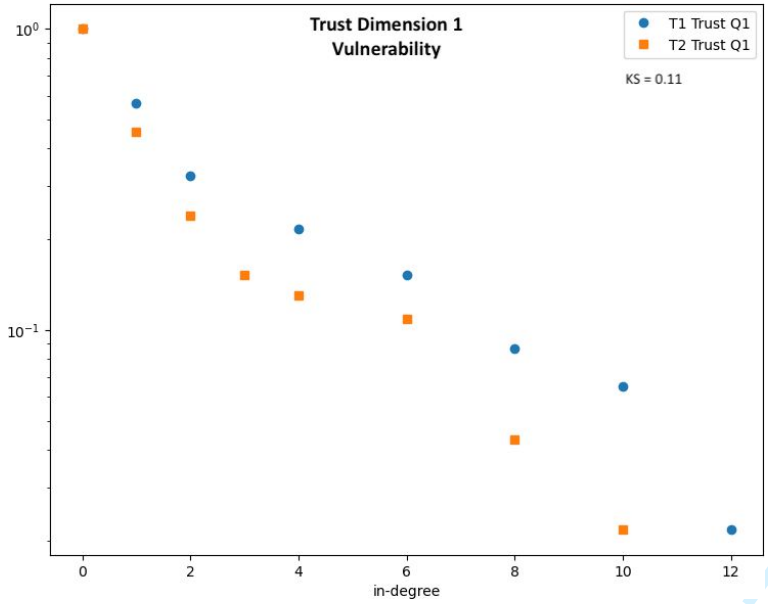
preparedness **PPI preparedness question Question 4: On a scale from (1) strongly disagree to (5) strongly agree, please rate the extent to which you agree with the following statement:** ***"I feel my organisation is prepared to support PPI research at this time"***

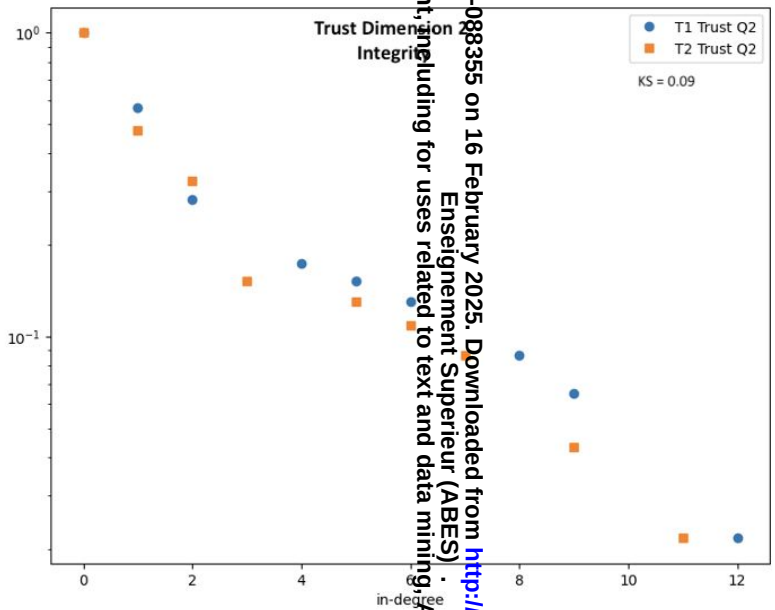
CLICK ONE OF THE FOLLOWING:

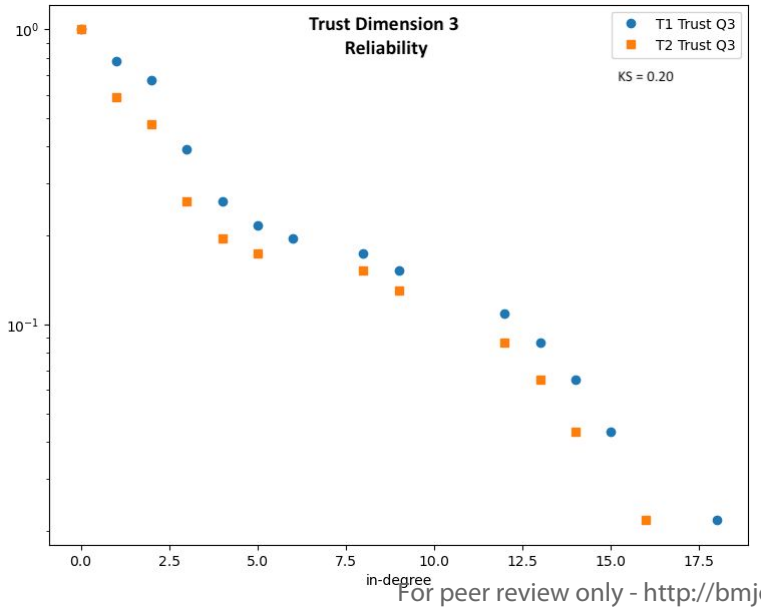
- **1 Strongly disagree** (1)
- **2 Disagree** (2)
- **3 Neither agree nor disagree** (3)
- **4 Agree** (4)
- **5 Strongly agree** (5)

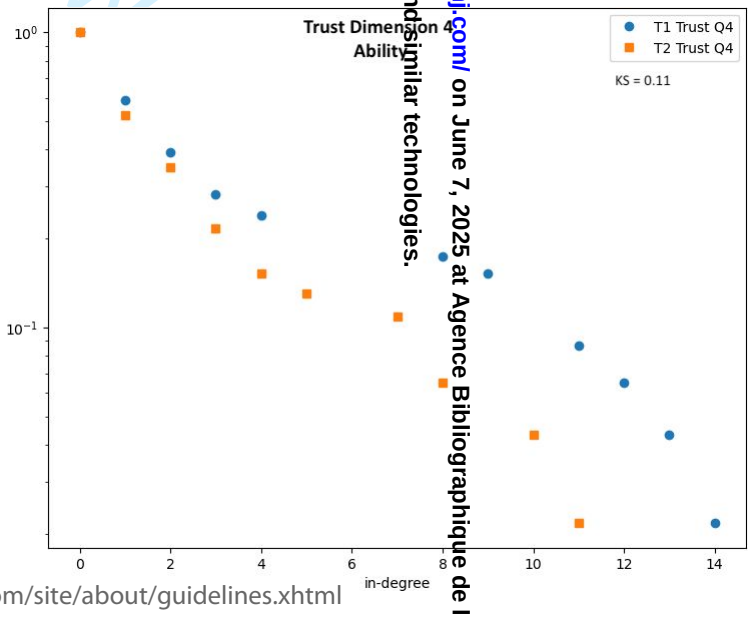
End of Block: Framing Questions

Distribution plots and Kolmogorov-Smirnov test

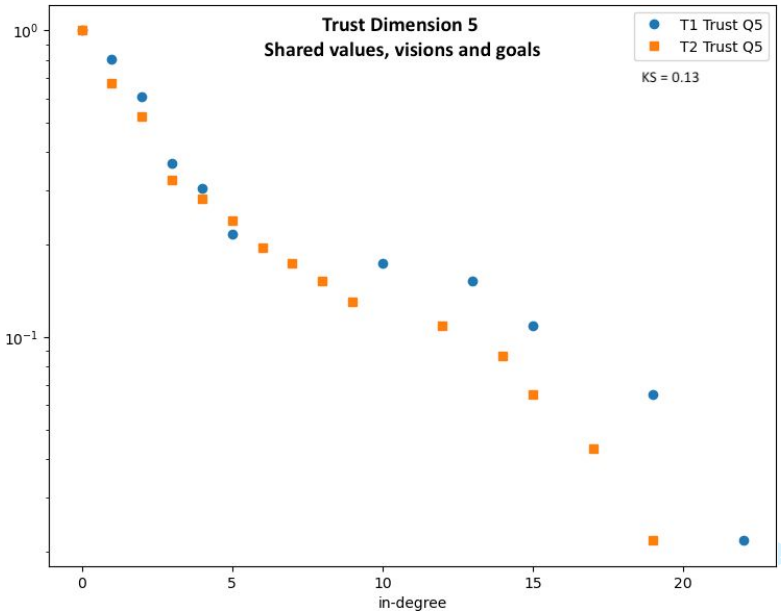


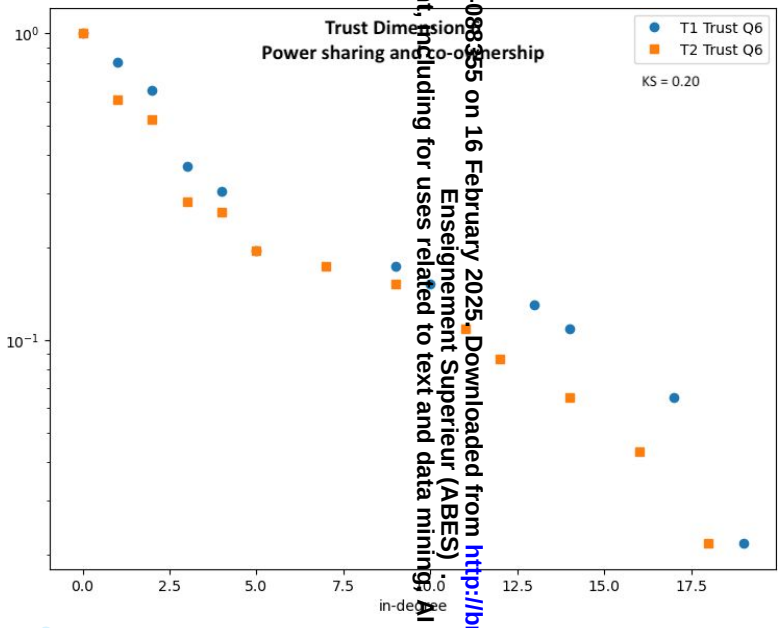


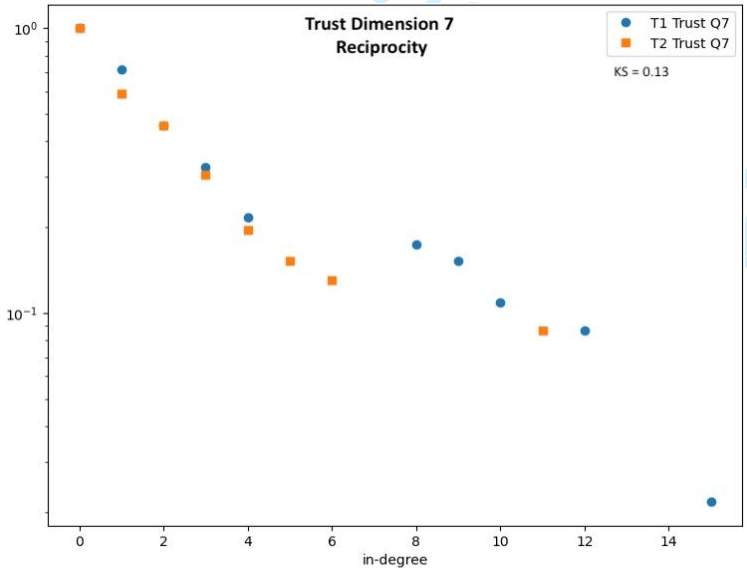




Distribution plots and Kolmogorov-Smirnov test

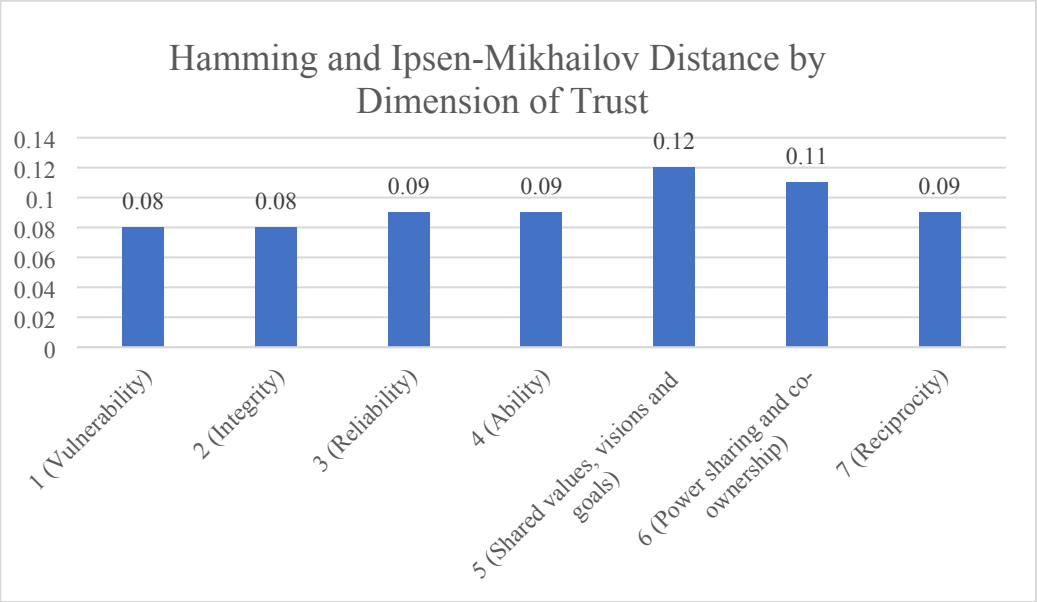






Distribution plots and Kolmogorov-Smirnov test

Hamming and Ipsen-Mikhailov Distance by Dimension of Trust Over Time



This metric combines the Hamming distance (Deza and Deza, 2009; Gao et al., 2010), which counts matching connections between two networks (i.e., trust dimensions at T1 and T2) and the Ipsen-Mikhailov distance, a spectral distance used to differentiate networks.(Ipsen and Mikhailov, 2003) Spectral distances are global measures that evaluate the difference between the whole structure, though can miss differences between small sub-structures. The HIM distance (Jurman et al., 2015) yields a 0 if two networks are identical, or 1 if they are opposite. For example, two networks that are identical will have a HIM distance of 0, while a complete graph (a network where everyone is connected to everyone else) compared to a graph with no connections, will have an HIM distance of 1.

References:

Deza MM and Deza E (2009) Encyclopedia of distances. *Encyclopedia of distances*. Springer, pp.1-583.

Gao X, Xiao B, Tao D, et al. (2010) A survey of graph edit distance. *Pattern Analysis and applications* 13(1): 113-129.

Ipsen M and Mikhailov AS (2003) Erratum: Evolutionary reconstruction of networks [Phys. Rev. E 66, 046109 (2002)]. *Physical review E* 67(3): 039901.

Jurman G, Visintainer R, Filosi M, et al. (2015) The HIM glocal metric and kernel for network comparison and classification. *2015 IEEE international conference on data science and advanced analytics (DSAA)*. IEEE, 1-10.