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Coexisting service-related factors preceding suicide: a network analysis

Malin Rex ,[1,2] Thomas Brezicka,[3] Eric Carlström,[1,4] Margda Waern,[5,6] Lilas Ali [1,2]

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[1]Institute of Health and Care Sciences, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden
[2]Affective Clinic, Sahlgrenska University Hospital, Gothenburg, Sweden
[3]Department for Quality and Patient Safety, Sahlgrenska University Hospital, Gothenburg, Sweden
[4]Centre for Person-Centred Care (GPCC), University of Gothenburg, Gothenburg, Sweden
[5]Institute of Neuroscience and Physiology, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden
[6]Psychosis Clinic, Sahlgrenska University Hospital, Gothenburg, Sweden

Correspondence to
Ms Malin Rex; malin.rex@gu.se

ABSTRACT

Objectives The overall objective was to analyse service-related factors involved in the complex processes that precede suicide in order to identify potential targets for intervention.

Design and setting Explorative network analysis study of post-suicide root cause analysis data from Swedish primary and secondary healthcare.

Participants 217 suicide cases reported to the Swedish national root cause analysis database between 2012 and 2017.

Primary and secondary outcome measures A total of 961 reported incidents were included. Demographic data and frequencies of reported deficiencies were registered. Topology, centrality indices and communities were explored for three networks. All networks have been tested for robustness and accuracy.

Results Lack of follow-up, evaluations and insufficient documentation issues emerged as central in the network of major themes, as did the contributing factors representing organisational problems, failing procedures and miscommunication. When analysing the subthemes of deficiencies more closely, disrupted treatments and staffing issues emerged as prominent features. The network covering the subthemes of contributing factors also highlighted discontinuity, fragile work structures, inadequate routines, and lack of resources and relevant competence as potential triggers. However, as the correlation stability coefficients for this network were low, the results need further investigation. Four communities were detected covering nodes for follow-up, evaluation, cooperation, and procedures; communication, documentation and organisation; assessments of suicide risk and psychiatric status; and staffing, missed appointments and declined treatment.

Conclusion The results of this study suggest that healthcare providers may improve patient safety in suicide preventive pathways by taking active measures to provide regular follow-ups to patients with elevated suicide risk. In some cases, declined or cancelled appointments could be a warning sign. Tentative results show organisational instability, in terms of work structure, resources and staffing, as a potential target for intervention, although this must be more extensively explored in the future.

Strengths and limitations of this study

- The data source was based on standardised reports performed by trained healthcare teams.
- The data were examined and categorised by four professionals, experienced in performing and peer-reviewing root cause analysis reports.
- In addition to analysis of reported frequencies of adverse events, network analysis was applied.
- Each network has been tested for robustness and accuracy.
- The main limitation is that a relatively small proportion of all suicides was submitted to the national database.

BACKGROUND

Suicide is one of the leading causes of death worldwide, affecting people of all ages, socioeconomic groups, and cultures. More than 700 000 suicides (1.3% of all deaths) occur globally each year, which exceeds the deaths due to malaria, HIV/AIDS, breast cancer, war and homicide.[1] For every completed suicide, there are indications of more than 20 other attempts.[2] Considering this and that the rate is markedly higher in people with psychiatric illness,[3–5] preventing suicide is a general priority in mental healthcare. Due to the complex and heterogenous nature of suicidal behaviour, fluctuating levels of suicide intent and the lack of reliable assessment tools, suicide preventive decision making is difficult.[6–8] Clinical actions depend not only on the competence of individual healthcare professionals, but also on patient safety management on a structural level.[9]

Postsuicide reviews commonly use root cause analysis (RCA) to identify service-related risks.[10 11] In Sweden, RCA has been a widespread method for investigating adverse events in healthcare for more than 15 years. The analyses are performed according to a standardised protocol by trained teams.[12] The RCA procedure has been exhaustively described elsewhere,[11 13 14] and the workflow of the Swedish RCA teams is identical to the steps listed there.[12] A short summary of the history of incident reporting and patient safety legislation in Sweden can be found in Fröding *et al*.[15]

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Network analysis is an approach to statistically analyse and visualise core elements of a data set. Application spans from mathematics and physics to social sciences and psychology. The method is useful for modelling complex patterns among correlated variables.[16 17] Over the last decade, a wide array of studies within the field of personality, psychopathology, and comorbidity has taken place.[16 18–37]

Previous research

Previous healthcare research on suicide prevention has focused mainly on single risk factors.[38 39] Besides highlighting the importance of providing treatment to underlying illness, it stresses the reduction of accessibility to lethal means,[40–45] combining immediate and long-term multilevel interventions,[42 43 46 47] building trustful staff–patient relationships and involving relatives,[48–50] conducting regular assessments in outpatient settings,[49 51 52] designing safer environments for inpatients,[53–56] following up earlier and maintaining closer supervision in the post-discharge period.[57–66] To reduce organisational risk factors, better communication among professionals, proper education and provision of adequate guidelines have been suggested.[15 49 52]

Previous studies based exclusively on postsuicide RCA material, including systematic reviews, meta-analyses and observational studies from inpatient[45 67] and outpatient settings,[62 67] Veterans Health administration facilities[68–72] and nursing homes[67 68] report inadequacies in cooperation,[62 68–70 72] accessibility to care,[45 69] assessments of suicidal risk[68–72] and follow-up[67] as the main deficiencies in suicide prevention.

Network analysis used in suicidal behaviour modelling suggests an association between suboptimal treatment of psychiatric illness and increased levels of suicidal ideation.[73–80] Feelings of thwarted belonginess,[74 75] entrapment, hopelessness and perceived burdensomeness[75 77 79 81] are also core phenomena of self-harm and suicidality. Physical illness, trauma, harassment and acute life stress due to economic or relational circumstances are examples of external individual factors associated with suicidal ideation.[76 81 82] Personalising treatment strategies, for instance, by using electronic devices for repeated ecological momentary assessment, has been suggested as an application of these findings.[73 75 83]

Network studies on service-related risk factors for suicides among persons in contact with health services are lacking. Therefore, this study aims to explore relationships of common deficiencies in healthcare preceding suicide, identify potential targets for clinical intervention and generate hypotheses for future research.

METHODS

This study followed the guidelines of the Strengthening the Reporting of Observational Studies in Epidemiology checklist for reporting cross sectional studies (online supplemental file A).

Material

The analysed material consists of 217 RCA reports concerning patient suicides uploaded to the Swedish national database for RCA (Nationellt IT-stöd för HändelseAnalyser - NITHA) from 2012 to 2017. The search criteria were: 'Type of consequence: suicide/suicide attempt'; 'death: yes'.[84] Information in NITHA is anonymised, so we could not link any information to actual patient records. The reports were produced by RCA teams from 12 of Sweden's 21 regions. The teams consisted of 3–4 investigators trained in RCA methodology. who were responsible for data collection, identifying deficiencies, listing possible contributing factors and proposing and evaluating adequate actions to avoid future recurrences. The data were collected from all data sources available to the team at the time of the investigation, including medical records, information from booking systems, data from external service settings, and qualitative data, such as interviews with healthcare professionals and interviews with relatives (64%, n=139). The final reports varied in terms of scope and content. In some cases, particular facts about the medical condition or specific circumstances were omitted. Although we do not know the exact background to this, it may have been done to protect the integrity of those deceased. As we only had access to the final RCA reports, we have not been able to scrutinise how the RCA teams processed the original raw data.

Suicide reports in the NITHA database

Table 1 shows the distribution of demographic characteristics among the included 217 patients, as stated by the RCA teams. Approximately half were between the ages of 18 and 49, and half were in contact with psychiatric services at time of death. Men were slightly over-represented. For two persons, gender was reported as 'other'. Mood disorders were recorded as the most common type of primary diagnosis for both sexes.

Data extraction and processing

A data coding tool was developed to organise the data into inductively constructed categories. The original protocol was tested by two teams (CBC, MD and EvH, MR), and refined until consistent themes and subthemes had been identified. The team members had different professional backgrounds (two psychiatrists, one psychiatric nurse and one psychologist) and were experienced in performing and peer-reviewing RCA reports at their own clinic. The teams worked independently but had regular meetings to discuss the data coding tool, which was audited by external reviewers and revised several times to cover all areas of interest in the RCAs. Every modification prompted a second review of previously reviewed cases. The final version of the data coding tool was used to derive data from all 217 cases. Data were double-checked for discrepancies; none were found in the final version of the dataset.

The two teams reviewed and coded all 217 RCA reports. The extracted raw data underwent a keyword-based

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Table 1 Patient demographics as reported to NITHA

	Total	Men	Women
	N=217	n=125	n=90
No of days since last documented contact with healthcare and date of suicide			
Mean	22.7		
Median ±SD	4±91		
Min–Max	0–1124		
Age			
7–17	10	5	5
18–49	109	61	48
50–64	51	28	23
65–74	28	18	10
75–84	14	10	4
≥85	2	2	0
Missing/omitted data	3	1	0
Primary diagnosis			
F0–F09 Organic, including symptomatic mental disorders	2	2	0
F10–F19 Mental and behavioural disorders due to psychoactive substance use	11	9	2
F20–F29 Schizophrenia, schizotypal, and delusional disorders	29	18	11
F30–F39 Mood (affective) disorders	92	53	38
F40–F49 Neurotic, stress-related and somatoform disorders	22	10	12
F60–F69 Disorders of adult personality and behaviour	10	2	7
F90–F98 Behavioural and emotional disorders with onset usually occurring in childhood and adolescence	12	5	7
Missing/omitted data	39	26	13
Setting (defined by medical records)			
Primary care	18	12	6
Psychiatry, inpatient	79	35	43
Psychiatry outpatient	58	41	16
Medicine, inpatient	17	13	4
Medicine, outpatient	2	2	0
Missing/omitted data	43	22	21

NITHA, Nationellt IT-stöd för HändelseAnalyser.

sorting of text strings in Microsoft Excel 2016 before classification, resulting in 499 registered deficiencies and 462 underlying, contributing factors. In the original RCA terminology, deficiencies are termed adverse events, and contributing factors root causes. Examples of typical cases are reported for each category in table 2. While some minor misclassifications in the original data were noted by the research teams, terminology used in the original NITHA reports (including definition of missing data) was retained.

In the original RCA reports each item could be reported multiple times. The range for some items varied from 1 to 6, depending on whether the RCA team had registered deficiencies in a merged or split form. To avoid skewed results, all observations were binarised (using the simple algorithm 'IF count value ≥0, THEN 1, ELSE 0') before being entered into the network model.

Data analysis

The synthesised network model contains two elements: nodes (sometimes called vertices), representing variables and edges (also called links) which represent pairwise association among nodes.[16 81] The network can be either directed, displaying the influential effect from one node to another, or undirected, where mutual influences are indicated by a line between two nodes without any direction.[16] Centrality indices, such as strength, betweenness and expected influence (EI), are employed to evaluate the network.[16 85] An overview of different types of networks and applicable models has been published by

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Table 2 Frequencies and percentages of reported variables

DEFICIENCIES N = 499							CONTRIBUTING FACTORS N = 462					
Node ID	Major theme	Description	Node ID	Subtheme	Example	Frequencies n (%)	Node ID	Major theme	Node ID	Subtheme	Example	Frequencies n (%)
FollowUp	Follow-up, continuity, and planning (n = 145)	Planning medical and non-medical treatment, health care, related problems, and continuity issues	NoAppoint	Treatment not scheduled or follow-up is not provided by next caregiver	Missed booking of future appointments.	89 (18)	Proc	Procedures, routines, and policies (n = 224)	Rout	Routine matters	Applicable routines were missing, incomplete or unknown to the coworkers.	224 (48)
			HcPlan	Deficiencies in healthcare plan	Missing info about objectives, strategies or planned interventions.	40 (8)						
			Decline	Patient declined contact	Patient had missed or declined an upcoming appointment.	16 (3)						
PsEval	Psychiatric evaluation (n = 149)	Regular assessment of mental health status and suicide risk	SuiRisk	Assessment of suicide risk	Suicide risk had not been evaluated.	77 (15)	Org	Organizational issues (n = 93)	Continu	Discontinuity issues	Instability in primary healthcare contact person.	22 (5)
			PsychEval	Evaluation of general mental condition	No evaluation of psychiatric status had taken place for a substantial period of time (defined by the RCA teams).	72 (14)			WorkStruct	Suboptimal work structure	Discrepancies among the coworkers about the concept of which tasks to execute, and how to execute them. Newly recruited coworkers were not properly introduced to tasks or procedures.	25 (5)
									Resourc	Lack of available resources	Shortages of hardware or software.	46 (10)
Coop	Cooperation (n = 112)	External or internal cooperation and shortages of shared resources such as staffing, hardware, software, or spaces	Coop	Suboptimal cooperation and/or responsibility issues	Unclear delimitation of responsibility.	86 (17)	Com	Communication and information (n= 68)	ExtCom	Suboptimal communication w. external unit	Insufficient communication among multiple involved units, for instance during transition from inpatient to outpatient services.	28 (6)
			Staff	Deficiencies in staffing, etc.	Understaffing.	26 (5)			ComNs	Administrative matters and/or unspecified other communication issues	Information was lost due to local administrative procedures. This category also includes cases where communication issues without any further specification were reported.	24 (5)
Doc	Documentation (n = 78)	Identifying discrepancies in documentation and transfer of information	Doc	Assessment not recorded	According to interviews, assessments were made but had not been recorded.	41 (8)			PatCom	Insufficient communication w. patients or relatives	Patients and/or relatives had not been provided with information about important details concerning future treatment.	10 (2)
			TransInfo	Suboptimal transfer of information	Important information was lost during referral or similar.	37 (7)			IntCom	Suboptimal internal communication	Miscommunication among team members at a single unit.	6 (1)

Continued

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Table 2 Continued

DEFICIENCIES N = 499							CONTRIBUTING FACTORS N = 462					
Node ID	**Major theme**	**Description**	**Node ID**	**Subtheme**	**Example**	**Frequencies n (%)**	**Node ID**	**Major theme**	**Node ID**	**Subtheme**	**Example**	**Frequencies n (%)**
Safety	Safety issues (n = 9)	Assessing risk of violence, need for extra monitoring, or possession of weapons; confiscation of means of suicide	Safety	Incomplete screening of means of suicide, risk of violence, need of extra monitoring and/or use of drugs	Patient had access to drugs or weapons. Patient in need of constant surveillance was left unattended.	9 (2)	Skills	Competence and education (n = 62)	MedSkills	Lack of competence regarding medical condition or level of risk	Due to insufficient training or experience, the coworkers did not respond adequately to acute signs of progress in severe somatic or psychiatric illness, leading to an undertreatment of these conditions.	23 (5)
									JurSkills	Lack of competence regarding juridical or organizational matters	Regulations regarding The Compulsory Mental Care Act (Swedish law 1991:1128) were not applied appropriately.	17 (4)
									SkillsNs	Unspecified competence issues	Includes cases where the RCA team had identified deficiencies related to competence, but where no further specification had been made.	22 (5)
Rel	Relatives (n = 6)	Engaging relatives in the patient's care	Rel	Absent/insufficient interaction with relatives	Relatives had not been contacted or invited to participate in planning of the care, despite the lack of formal hindrance to participation.	6 (1)	Tech	Technical equipment and systems (n = 15)	Tech	Malfunctional design of devices or rooms	Failing security systems. Staff lacked appropriate access to important medical records or to particular spaces at the ward. Poorly designed inpatient rooms. Ligature points were discovered.	15 (3)

RCA, root cause analysis.

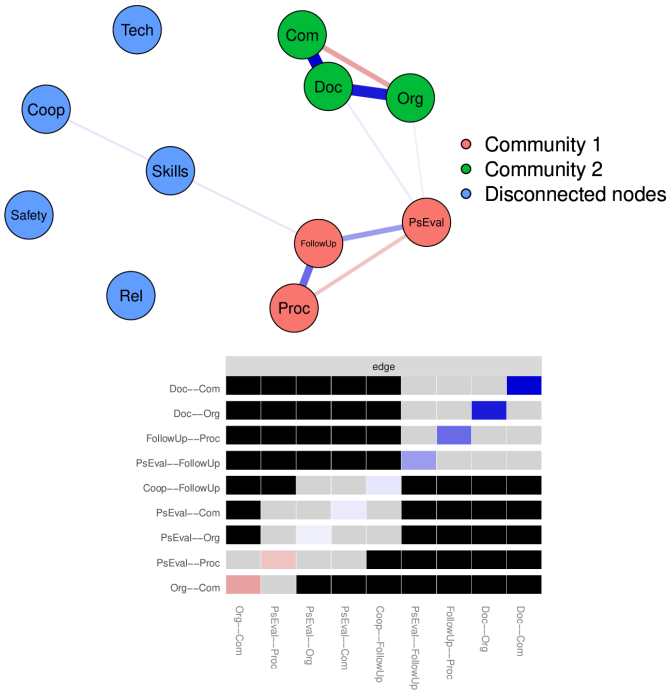

Figure 1 Major network: black fields show significant differences (alpha=0.05) of edges.

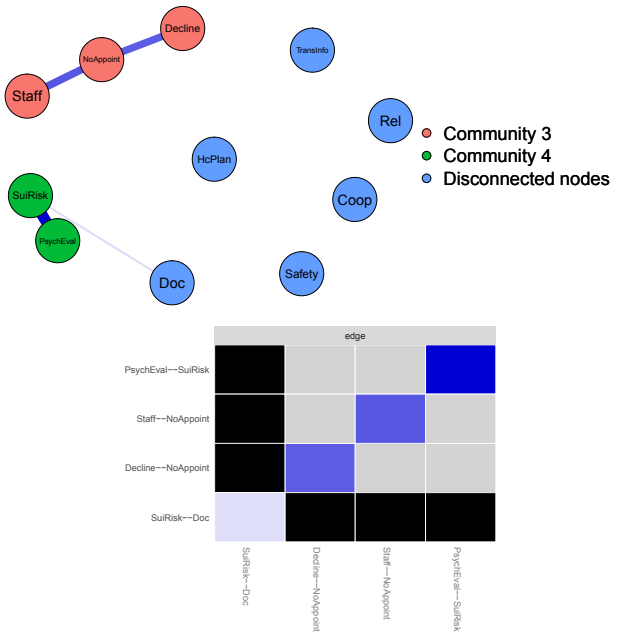

Figure 3 Deficiencies network: black fields show significant differences (alpha=0.05) of edges.

Hevey, 2018.[23] For a further discussion on psychometrics and network estimation, we refer to previous researchers in this field.[31 86–90]

Three networks were produced: one giving an overview of the major themes (figures 1 and 2), another showing subthemes of deficiencies (figures 3 and 4) and a third covering subthemes of contributing factors (online supplemental file B). Frequencies and percentages are reported for each variable (table 2), alongside the centrality indices and stability measures (figures 1–4, table 3). Data were analysed using IBM Statistical Package for the Social Sciences V.25 and R V.3.5.0 (bootnet package V.1.4.3, ggplot2 V.3.3.5, igraph package V.1.2.6, qgraph package V.1.6.9, IsingFit package V. 0.3.1).[91–97] To visualise the dependencies, we used an undirected network (formally called a pairwise Markov random

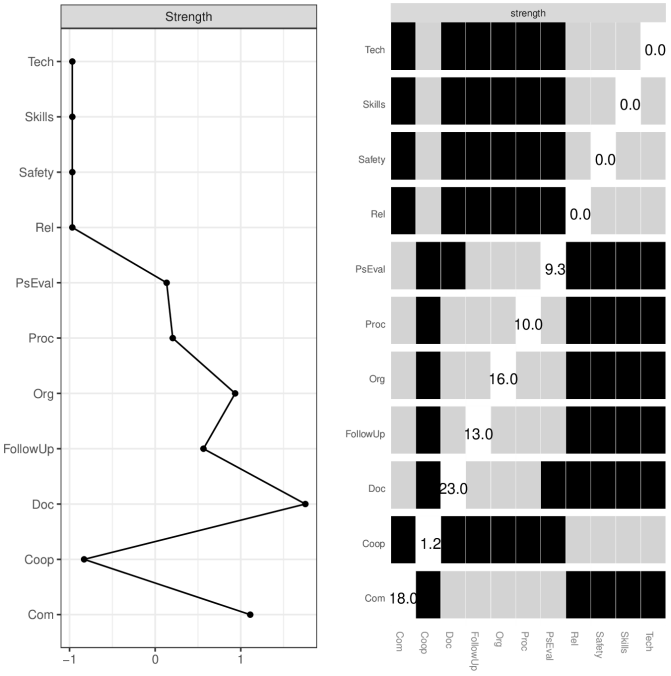

Figure 2 Major network: standardised centrality index and significant differences (alpha=0.05) of node strength (black fields).

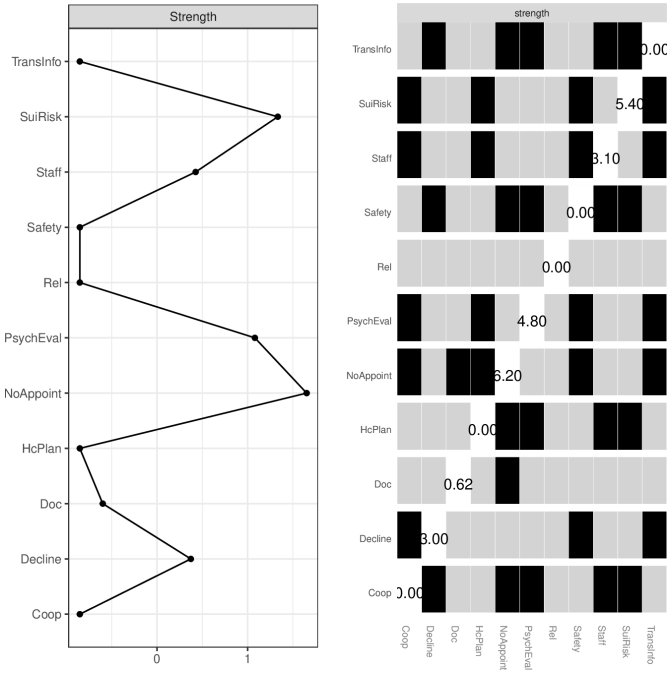

Figure 4 Deficiencies network: standardised centrality index and significant differences (alpha=0.05) of node strength (black fields).

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Table 3 CS-coefficients for each network (cut-off=0.25)

Centrality index	Major network	Deficiencies network	Contributing factors network
Edge	0.75	0.594	0.13
Closeness	0	0	0
Betweenness	0	0	0
Expected influence	0.75	0.594	0
Intercept	0.21	0.438	0.52
Strength	0.75	0.594	0

CS, correlation stability.

field).[28 87 98] Relevant relationships among nodes were estimated using IsingFit package which uses an enhanced least absolute shrinkage and selection operator, based on the Ising Model. The operator reduces spurious edges by suppressing minimal connections to exactly zero. Selection is performed by combining logistic regression (l_1-regularised) and a model selection based on the Extended Bayesian Information Criterion (EBIC).[96] Since the network structures were sparse, the EBIC hyperparameter (γ) was adjusted to 0 after careful consideration and comparisons of different settings. A γ set to 0 (can vary from 0 to 1, default is 0.25) results in a lower shrinkage of estimated connections. As simulation studies have shown, the likelihood of false positives is low and the specificity will still be higher compared with a non-regularised partial correlation network.[23 88 99] The estimated networks were then bootstrapped for accuracy and stability using the bootnet function, which performs a non-parametric bootstrap to calculate the 95% bootstrapped CIs for the edges by resampling the data with replacement 2500 times per network. The networks were visualised with the plotting tools in qgraph, using the force-directed layout 'spring', which employs the Fruchterman-Reingold algorithm and draws nodes with higher centrality towards the centre.[93 100] Lastly, network communities were calculated using the walktrap algorithm and plotted with igraph, qgraph and ggplot2 plotting tools.[92 94 97] The data and R code necessary to reproduce our results can be found on The Open Science Framework repository.[101–104]

Patient and public involvement

Neither patients nor the public were involved in this study.

RESULTS

Frequencies and percentages of reported variables

Frequencies and percentages for identified categories of deficiencies and contributing factors are reported in table 2.

Deficiencies (499 in total) were identified and classified under six major themes. The three most frequently reported categories concerned psychiatric evaluation, follow-up and cooperation. Typical cases involved patients who were referred from inpatient to outpatient services or changes in primary clinical contacts, both of which could result in missed appointments or incomplete assessments of health status. In 28% of the cases involving follow-up, healthcare planning that could have provided a framework for treatment during the transition was also lacking. Seventy-seven per cent of the deficiencies categorised as problems in cooperation were linked to unclear delimitation of responsibility. Lack of adequate information was also a relatively common explanatory factor and was identified in 16% of all cases. In contrast, deficiencies concerning safety and relatives were rare.

In line with the structure of the RCA protocol, the 462 contributing factors formed five major themes (table 2). Nearly half of the factors pointed towards failing procedures, routines, or guidelines as contributors. Examples included poor compliance to, or insufficient knowledge about an existing policy, or lack of guidelines that could be applied in a specific context. Suboptimal work structures, communication problems and insufficient competence regarding medical, juridical or organisational matters were also reported as common.

Network stability

Correlation stability coefficients (CS-coefficients) denote the estimated maximum number of cases that can be dropped from the data to retain a correlation of at least 0.7 between statistics, based on the original network data and statistics computed with fewer cases (with 95% probability). The coefficient should not be below 0.25 and is preferably above 0.5.[87 105] The CS-coefficients for each of the three networks (the major network, deficiencies network and contributing factors network) are shown in table 3. As CS-coefficients for the Contributing factors network were below the cut-off value, indicating instability, further investigations are required before any final conclusions can be drawn.[87] The visualisation of this network is included in online supplemental file B, along with the centrality indices calculated for this subset.

Central and peripheral nodes in the network

The centrality indices node strength and edge strength were included to quantify impact on each network structure. Node strength is defined as the total sum of the magnitude of each of its edges. Edge strength in a partial correlation or regularised network reflects the magnitude of the pairwise relationship between two nodes, while

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controlling for indirect influences via other nodes.[23 88] The centrality indices closeness, betweenness and EI were examined, but excluded from the main section of this paper as the CS-coefficients for closeness and betweenness were below cut-off and EI did not add anything to the interpretation that was not already explained by node strength. Calculated values for these indices are included in online supplemental files C–E.

The major network and significant differences of edges are shown in figure 1.

As shown in both figures 1 and 2, nodes representing documentation, communication, organisation, follow-up, procedures and psychiatric evaluation were central, compared with nodes related to safety, competence, contact with relatives, technical issues and cooperation. Although the nodes involved in this subset all scored high in strength, two non-significant, negative connections were found: (1) between organisation and communication, and (2) between psychiatric evaluation and procedures, which may reflect how data were registered by the RCA teams.

In the Deficiencies network (figure 3), missed appointments, particularly the absence of booked follow-ups but also cancellations made by the patient, scored high in node strength. Consequently, missed assessments of suicide risk and continuous re-evaluation of the psychiatric status, were also central, along with the node representing shortages in staff.

In relation to these nodes, the nodes representing administrative problems, such as missed referrals or other types of transferred information, safety issues, suboptimal contact with relatives, healthcare plan being either absent or incomplete, and assessment not being recorded were more peripheral (figure 4).

The third network, representing contributing factors, was too instable to estimate. Although the nodes for work structure, resources, competence and continuity had the highest node strength centrality, the differences were not significant. Our recommendations are to examine these more thoroughly in a future study with a larger sample. The topology and centrality indices for the Contributing factors network are shown in online supplemental file B.

Detected communities

Communities were detected using the walktrap algorithm.[92] The nodes belonging to a community are colour marked in the visualisations of the networks in figures 1 and 2.

Two communities were present in the major network (figure 1):

1. The nodes for the deficiencies psychiatric evaluation, follow-up, and the contributing factor for procedures, routines and policies.
2. The nodes for the deficiency communication and the nodes representing the contributing factors organisation and communication.

Analysis of the deficiencies network (figure 2) resulted in two detected communities. The first included the nodes representing understaffing, declined/missed appointments, and cases where future appointments had not been booked. The second covered the nodes representing assessments of suicide risk and of the overall mental condition.

DISCUSSION

The results of this study suggest that reported adversities are linked to a group of activities, rather than to single mistakes. Providing suicidal patients with regular assessments, for instance, and proposing adequate actions depends not only on the personal conditions of the evaluating clinician and the patient being assessed, but also on proper work structures, good intrateam communication, adequate routines and well-known procedures, and sufficient documentation of planned and performed activities.

There are three main findings of this study. First, missed and declined appointments are central features when examining elements occurring prior to the suicide. Together they account for more than a fifth of the total amount of deficiencies. We have not examined the positive effects of feedback loop systems which enhances the ability for healthcare providers to react when a patient does not turn up on scheduled meetings. Nor have we investigated cases with negative correlations between treatment cancellations and suicide. However, one hypothesis drawn from our results and extrapolated conclusions from previous studies,[51 52 57 58 60–63 65–72] is that any disruption in treatment is negative, and cancellations made by the patient could be an early warning sign of an ongoing exacerbation of the suicidal process. During phases of acute suicidality or in the early stages of recovery from a suicide attempt, the well-being of the patient is frail, and the suicide risk may fluctuate rapidly.[58 61 64–66] Establishing a backup system, which safeguards follow-up plans and alerts healthcare staff when patients cancel planned appointments, could help improve patient safety. Second, many nodes are still disconnected. Even if it is likely that there is an underlying covariance, the correlation is not independently significant. The sparsity of the networks could be explained by the estimation procedure. Each network has been regularised to reduce false positive connections and produce parsimonious graphs. When comparing them with networks based on partial correlation matrices, many edges have been omitted due to the penalisation. It is therefore likely that other patterns would appear if more data were entered. Third, the nodes representing security, technical issues and contact with relatives have both low frequencies and low centrality. This means that adversities related to these areas are rarely reported. One reason for this can be the very nature of the type of failures that can occur in these areas. Denied access to an important medical record system at a specific time rarely affects more than one or a few team members at a time. Ligature points, once removed, do not reappear at the exact same location.

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Establishing and maintaining stable work conditions, on the other hand, is more elusive. The concept of organisational prerequisites to provide safe interventions to suicidal patients is subjective which could lead to a higher rate of recurrences of management related issues. While adverse events concerning security at the inpatient facilities were rare, the transition to outpatient services was frequently mentioned in the post-mortem audits. Transitions imply a change in primary caregiver and a shift from short-term to long-term treatment goals. A connection to elevated risk levels could be expected, although the direct relationship has not been investigated in this study. To gain more knowledge about the mechanisms involved, network studies covering these steps of the process are needed. Even though interviews with relatives were included in 64% of the reports, their perspective were only reflected in 1% of the deficiencies (table 2). This situation has been previously described by Bouwman et al.[50] . After examining policies from 15 healthcare organisations and spoken to 35 stakeholders (including patient, families and their counsellors, national regulators and professionals) they concluded that involvement by relatives, insofar they had been involved, rarely extended beyond aftercare and information provision.[50] With this in mind, studies based on the narratives of relatives would probably complement and enrich our results.

We acknowledge that from a general point of view, some of our findings are similar to the conclusions drawn by our colleagues in the same field. Suicide risk is multifactorial, and decisions about appropriate safety measures are dependent on factors on both individual and structural levels.[5 6 10 38 40 42 44 46 48 49 51 53–55 57 58 60–64 66 68–70] However, following the argumentation of Fried and Robinaugh (2021) on complexity, adverse events cannot be prevented by understanding the single components alone, neglecting the interactions among them.[106] If the value of a unique node is determined not only by the intrinsic properties of the node itself, but by its relations to other objects, the study of single factors will not yield any ultimate answers about how to prevent undesired events. To gain more knowledge, we must first examine the dynamics of the systems from which adversity arises.

CONCLUSION

Network analysis adds to previous research in patient safety by elucidating patterns which may be unclear if only incident rate is considered. The results show that failed assessments and cancelled treatments during follow-up are both frequent and have a high centrality, thus functioning as a warning sign for exacerbation. Organisational instability, in terms of understaffing, shortages of resources and suboptimal work procedures are also prominent features of the networks. Although comparative studies are needed before any final conclusions can be drawn, focusing on these areas may improve patient safety in suicide prevention.

Strengths and limitations

Strengths of the study include data collected from NITHA, the only open national resource in Sweden for the dissemination of RCA reports. These reports were produced in a standardised manner by trained RCA teams. The data were examined and categorised by four professionals, all experienced in performing and peer-reviewing RCA reports. Considering the dynamic nature of deficiencies in healthcare where underlying factors are rarely sharply outlined, but rather multilayered, network analysis can bring new and valuable insights of risk-prone areas.

The study also has several limitations. This was a cross-sectional study, limiting the capacity to identify the directions of effects. Since we obtained our data exclusively through the NITHA system, other postsuicide investigations were not included. Because regional institutional praxis concerning submission to the NITHA database varied, RCA reports cannot be considered representative for the country of Sweden. A relatively small proportion of all suicides were submitted to the database, and therefore, selection bias cannot be ruled out. The RCA methodology is designed to scrutinise organisations and detect possible causes for systematic negative output. Consequently, the reported findings may focus on incidental discoveries, rather than some latent factor which lies beyond the scope of the protocol. Moreover, since RCA aims to identify organisational vulnerabilities, the reports lack certain details concerning the patients themselves. As we did not have access to original records, we have not been able to verify the accuracy of the content in the RCA reports. Therefore, our findings will reflect any misclassification done by the RCA teams during the initial investigation process. Lastly, the classification tool used by the auditing teams has not been validated by independent reviewers. The data were qualitatively categorised and could have been organised differently.

FUTURE RESEARCH

Based on the findings of this study, we suggest further research on security systems which help healthcare providers to react when patients drop out of treatment. Considering the relatively low number of observations, we also recommend future network studies based on a larger sample. To gain more insights into the perspectives of patients and relatives, network studies based on their experiences would be a fruitful approach.

Twitter Lilas Ali @lilasali

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ORCID iDs
Malin Rex http://orcid.org/0000-0003-4184-7606
Lilas Ali http://orcid.org/0000-0001-7027-4371

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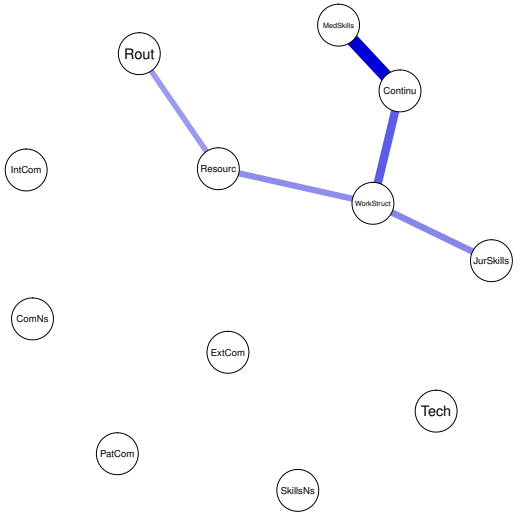
STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Title page
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1-2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4-8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	4-7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-10
Bias	9	Describe any efforts to address potential sources of bias	4-7, 15-16
Study size	10	Explain how the study size was arrived at	4-5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-8
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	7-8
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	N/A
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5-6
		(b) Indicate number of participants with missing data for each variable of interest	5-6
Outcome data	15*	Report numbers of outcome events or summary measures	9-11

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7-8, 11
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	9-13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15-16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	13-15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.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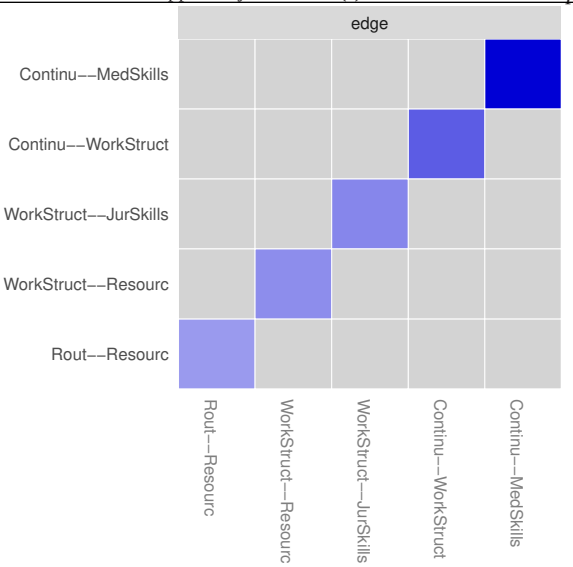
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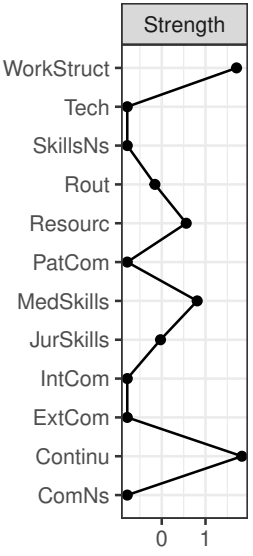
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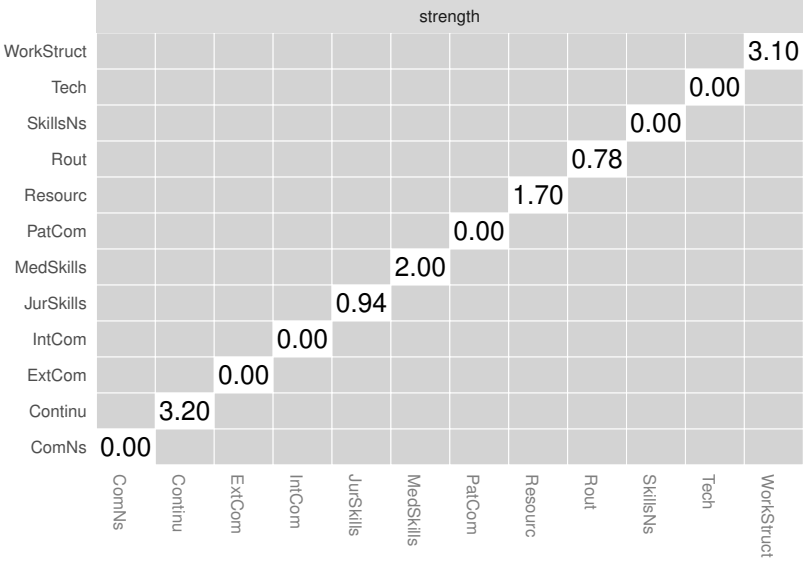
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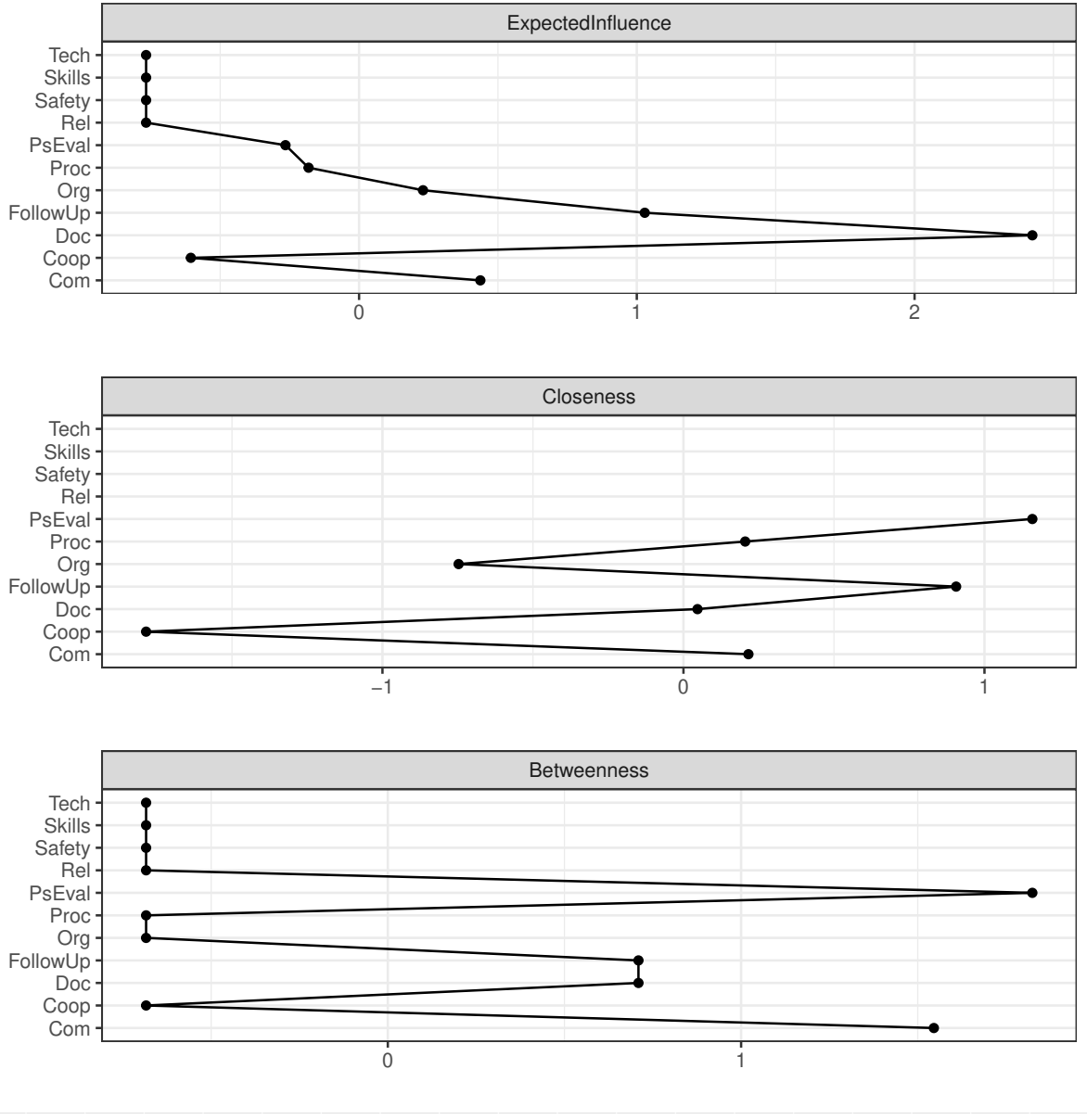
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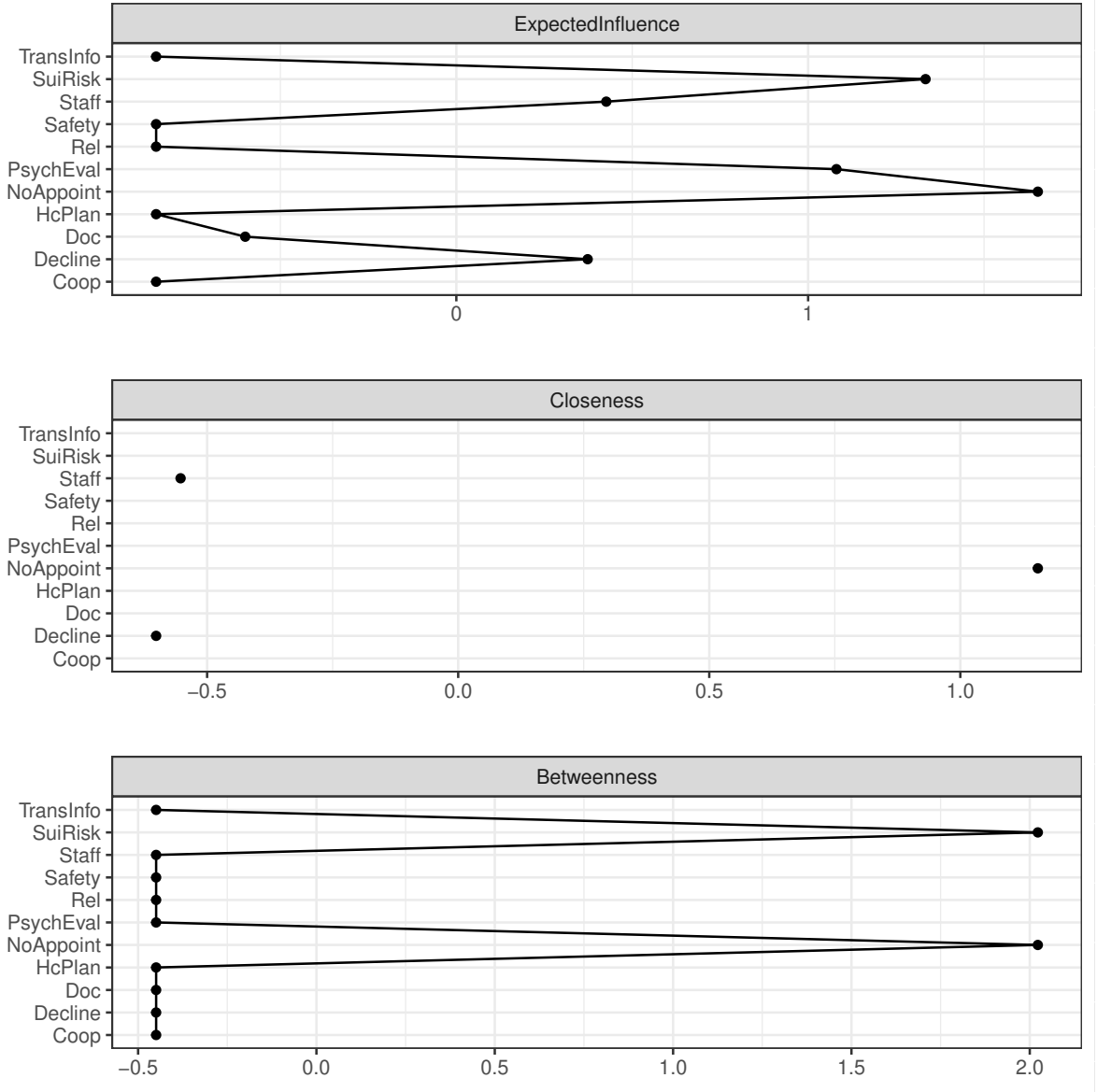
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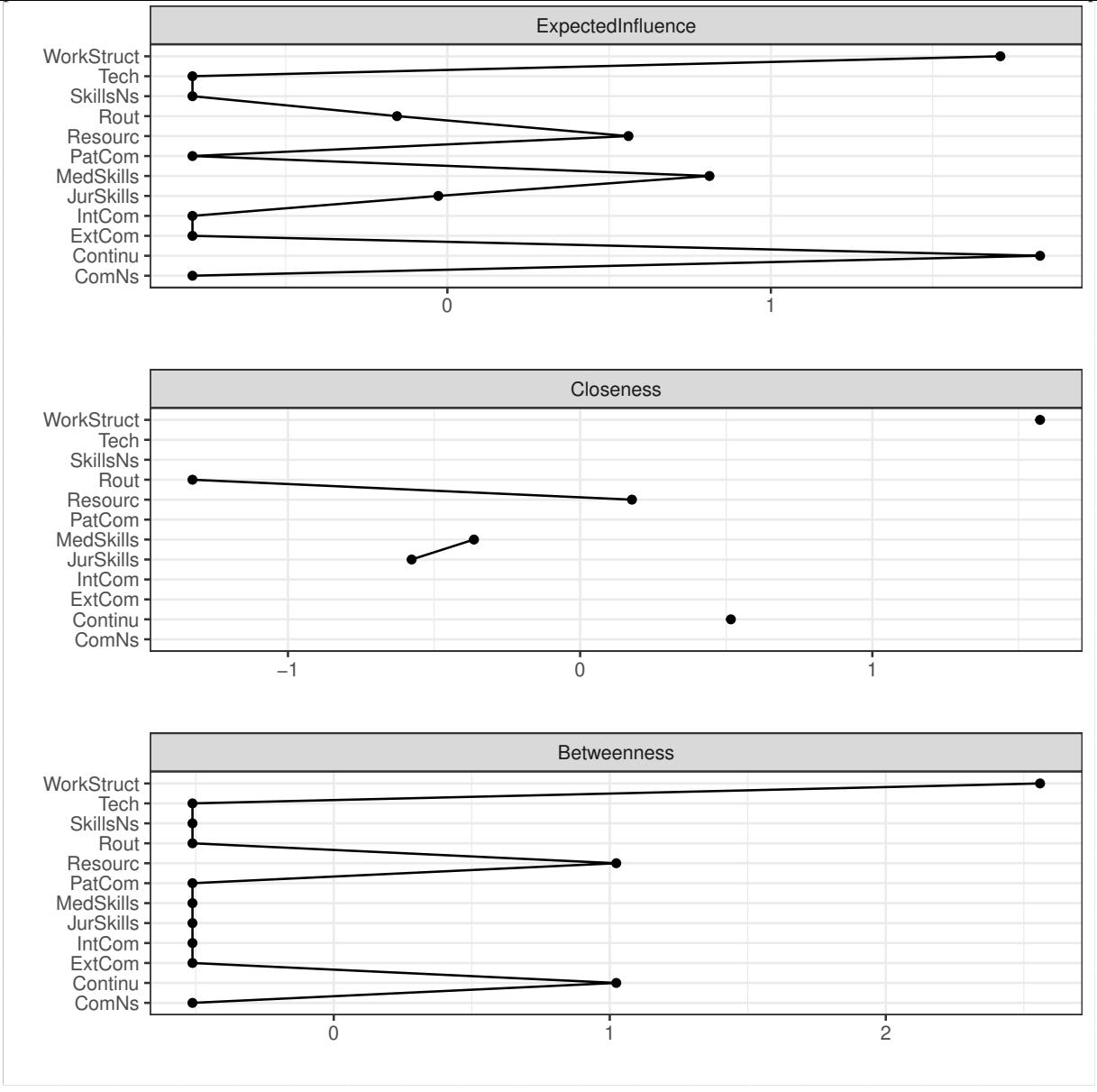
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