

BMJ Open

BMJ Open is committed to open peer review. As part of this commitment we make the peer review history of every article we publish publicly available.

When an article is published we post the peer reviewers' comments and the authors' responses online. We also post the versions of the paper that were used during peer review. These are the versions that the peer review comments apply to.

The versions of the paper that follow are the versions that were submitted during the peer review process. They are not the versions of record or the final published versions. They should not be cited or distributed as the published version of this manuscript.

BMJ Open is an open access journal and the full, final, typeset and author-corrected version of record of the manuscript is available on our site with no access controls, subscription charges or pay-per-view fees (<http://bmjopen.bmj.com>).

If you have any questions on BMJ Open's open peer review process please email info.bmjopen@bmj.com

BMJ Open

Coexisting service related factors preceding suicide: a network analysis

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2021-050953
Article Type:	Original research
Date Submitted by the Author:	15-Mar-2021
Complete List of Authors:	<p>Rex, Malin; University of Gothenburg, Institute of Health and Care Sciences, Sahlgrenska Academy; Sahlgrenska University Hospital, Affective clinic</p> <p>Brezicka, Thomas; Sahlgrenska University Hospital, Department for quality and patient safety</p> <p>Carlström, Eric; University of Gothenburg, Institute of Health and Care Sciences, Sahlgrenska Academy; University of Gothenburg, Centre for Person-Centred Care (GPCC)</p> <p>Waern, Margda; University of Gothenburg, Institute of Neuroscience and Physiology, Sahlgrenska Academy; Sahlgrenska University Hospital, Psychosis Clinic</p> <p>Ali, Lilas; University of Gothenburg, Institute of Health and Care Sciences, Sahlgrenska Academy; Sahlgrenska University Hospital, Affective Clinic</p>
Keywords:	Suicide & self-harm < PSYCHIATRY, PSYCHIATRY, Adult psychiatry < PSYCHIATRY, Depression & mood disorders < PSYCHIATRY

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Coexisting service related factors preceding suicide: a network analysis

Malin Rex^{1,2}, Thomas Brezicka⁴, Eric Carlström^{1,3}, Margda Waern^{5,6}, Lilas Ali^{1,2}.

¹ University of Gothenburg, Institute of Health and Care Sciences, Sahlgrenska Academy Gothenburg, Region Västra Götaland, Sweden

² Sahlgrenska University Hospital, Affective clinic Gothenburg, Region Västra Götaland, Sweden

³ University of Gothenburg, Centre for Person-Centred Care (GPCC) Gothenburg, Region Västra Götaland, Sweden

⁴ Sahlgrenska University Hospital, Department for quality and patient safety Gothenburg, Region Västra Götaland, Sweden

⁵ University of Gothenburg, Institute of Neuroscience and Physiology, Sahlgrenska Academy Gothenburg, Region Västra Götaland, Sweden

⁶ Sahlgrenska University Hospital, Psychosis Clinic Gothenburg, Region Västra Götaland, Sweden

Correspondence to: Malin Rex

POSTAL ADDRESS

University of Gothenburg, Institute of Health and Care Sciences
Box 457
405 30 Göteborg, Sweden

malin.rex@gu.se

+46-761199908

Keywords: Suicide, Patient safety, Psychiatry, Mood disorders, Self-Injurious Behavior

Word count: 2675 (excluding title page, abstract, tables, acknowledgements, contributions, and references.)

ABSTRACT

Objectives

The overall objective was to illustrate the interdependency of events involved in the complex processes that precede suicide. More specifically, we aimed to map clusters in the synthesized network of events, root causes, and suggested actions reported in post-suicide RCA data and to explore potential interactions among those clusters and the preventive measures recommended by the RCA team.

Design and setting

Explorative, retrospective study of post-suicide RCA data from Swedish primary and secondary healthcare.

Participants

217 suicide cases reported to the national database for RCA (NITHA) between 2012 and 2017.

Primary and secondary outcome measures

Demographic data and frequencies of reported deficiencies and actions were registered. Themes were identified for correlation tests to produce a network of interlinked nodes and calculate network metrics (degree, betweenness and Eigenvector scores).

Results

We identified 499 adverse events, 462 root causes, and 700 suggested actions. The network analysis yielded 25 nodes clustered in four patient safety domains. The largest cluster, involving the patient–caregiver interface, was dominated by the node focused on evaluation. A second cluster involved interactions among co-workers and recommendations directed towards optimizing organizational resources and improving cooperation. The third cluster involved the interface between two or more units and included follow-up, continuity, and planning as areas needing improvement. The final and smallest cluster involved safety issues in the care environment.

Conclusion

Network analysis can be a useful tool to uncover structures relevant to suicide prevention in healthcare settings. In planning interventions, it is important to look beyond single deficiencies and to employ multifactorial strategies. Detected risk factors increases the likelihood of the presence of another risk factor from the same cluster. Also, implemented actions will probably influence multiple factors within the same cluster, which must be considered when evaluating the effect of a taken intervention.

SUMMARY - STRENGTHS AND LIMITATIONS OF THIS STUDY

- To our knowledge, this is the first network study based on post-suicide audits.
- The study provides new insights, not only on single factors, but on risk-prone clusters in suicide prevention.
- Data were collected from NITHA, the only open national resource in Sweden for the dissemination of RCA reports.
- This study does not focus on details concerning the patients, but on how the suicide prevention was organized.
- A relatively small proportion of all suicides were submitted to the database.

BACKGROUND

Suicide is a serious public health issue that affects people of all ages, socio-economic groups, and cultures. Approximately 800 000 suicides occur globally each year, accounting for 1.5% of all deaths. For every completed suicide, there are indications of more than 20 other attempts.[1] Considering this and that the rate is markedly higher in people with psychiatric illness,[2, 3] preventing suicide is a focus in mental healthcare. Because of the complex and heterogenous nature of suicidal behavior, fluctuating levels of suicide intent and the lack of reliable assessment tools, suicide preventive decision making is difficult.[4-6] Clinicians need to know which interventions may be helpful for the suicidal patient, and management and policy makers need to know how to organize care to provide safe preventive and recovery pathways to patients with elevated risk of suicide. Clinical actions depend not only on the competence of individual healthcare professionals, but also on patient safety management on a structural level.[7]

Previous healthcare research on suicide prevention has focused mainly on individual risk factors,[8, 9] highlighting the importance of reducing access to lethal means,[10-14] combining immediate and long-term multi-level interventions,[12, 13, 15, 16] building trustful staff-patient relationships, conducting regular assessments in outpatient settings,[17] designing safer environments for inpatients,[18, 19] and following up earlier and maintaining closer supervision in the post-discharge period.[20-27]

Post-suicide reviews commonly use root cause analysis (RCA) to identify service-related risks.[28, 29] In Sweden, RCA has been recommended for investigating adverse events in healthcare for the past 15 years.[30] Previous studies on RCA material, including systematic reviews, meta-analyses, and observational studies report inadequacies in cooperation,[25, 31-34] accessibility to care,[32]

1
2
3 assessments of suicidal risk,[31-33, 35] and follow-up[36] as the main root causes of suicide in
4 healthcare.
5

6
7 In a study of mandatory, non-standardized post-suicide audits submitted to the Swedish Health and
8 Social Care Inspectorate during 2015, recommendations for improvements were often single
9 informational interventions that often did not correspond to the deficiencies they were meant to
10 mitigate.[37] This suggests a need for patient safety research that acknowledges the complexity of
11 the suicidal process by elucidating interactions among various factors. In the current study, we used
12 network analysis to map and analyse interdependencies among adverse events, root causes, and
13 recommended actions in post-suicide RCAs submitted to a national database.
14
15
16
17
18
19

20 **METHODS**

21 **Material**

22
23 The analysed material consists of 217 RCA reports concerning patient suicides uploaded to the
24 Swedish national database for RCA (NITHA) from 2012 to 2017 (search criteria: “Type of
25 consequence: suicide/suicide attempt”; “death: yes”). Information in NITHA is anonymized, so we
26 could not link any information to actual patient records. The RCA reports were produced by RCA
27 teams from 12 of Sweden’s 21 regions. Data sources included interviews with healthcare
28 professionals, interviews with relatives (64%, n = 139) and medical records.
29
30
31
32
33
34
35

36 **Development of data collection tool and data extraction from RCA reports**

37
38 A data collection tool was developed to organize the data into inductively constructed thematic
39 categories. The original protocol was tested by two teams (CBC, MD and EvH, MR), and refined until
40 consistent themes and subthemes had been identified. The team members had different
41 professional backgrounds (two psychiatrists, one psychiatric nurse, and one psychologist) and all
42 were experienced in performing and peer-reviewing RCAs at their own clinic. The two teams worked
43 independently but had regular meetings to discuss and modify the data collection tool. The data
44 collection tool was audited by external reviewers and modified several times to cover all areas of
45 interest in the RCAs. Every modification prompted a second review of previously reviewed cases. The
46 final version of the data collection tool was used to collect data from all 217 cases. Data were double-
47 checked for discrepancies; none were found in the final version of the dataset.
48
49
50
51
52
53
54

55
56 All 217 RCAs were reviewed and coded by the two teams. The extracted raw data underwent an
57 algorithm- and keyword-based sorting of text strings in Microsoft Excel 2016 before being manually
58 distributed into the final categories. While some minor misclassifications of adverse events and root
59
60

causes were noted by the research teams, terminology used in the original NITHA reports was retained.

Suicide reports in the NITHA database

Table 1 shows the distribution of demographic characteristics among the 217 patients in the RCA reports. For two persons, gender was reported as “other.” Men were slightly overrepresented. Mood disorders were recorded as the most common primary diagnoses for both sexes. Approximately half were between the ages of 18 and 49, and half were in contact with psychiatric services at time of death. The median number of days from last contact with healthcare and date of suicide was 4 days (mean 22.7 days, range 0–1124 days; data not shown).

Table 1. Patient demographics as reported to NITHA

	Total N = 217	Men n = 125	Women n = 90
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 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 data	39	26	13
SETTING			
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 data	43	22	21

Construction of network and selection of measures

Based on an adjacency matrix, we synthesized an undirected network showing reciprocal connections among nodes, in which nodes were formed by categories of adverse events, root causes, and actions. Significantly correlated ($P \leq 0.05$) connections to other nodes were marked by links.[38, 39] In graph theory, nodes and links are called “vertices” and “edges,” but for clarity we use the simpler terms “nodes” and “links.”

The width of the link was determined by the strength of the correlation. Although the dataset contained information about negative correlations, no such correlation was significant, so none is presented in the network.

To evaluate the connections in the network, we measured three basic values of centrality: degree, betweenness, and eigenvector scores: degree detects highly connected nodes; betweenness measures the number of times a node acts as a bridge between two adjacent nodes; and eigenvector centrality is a composite score used to perform leading eigenvector cluster analyses.[38-43]

Nodes with a combined high score in network analysis were centralized in the network. A product of frequency, degree, and betweenness was calculated to identify principal nodes (“sentinel nodes”) in each cluster. In social network analysis, eigenvectors are sometimes used to identify hubs of influential people or groups in the network. As the nodes in our network did not actively influence each other, we considered the combined score more useful for calculating sentinel nodes. When a node of a more general character (e.g., the themes *Procedures, routines, and policies; Structural changes in procedures; No/unclear action*) yielded the highest combined score, it was replaced by the subsequent node.

Data analysis

Frequencies and percentages are reported for categorical variables. Spearman’s rho correlation coefficient tests were performed to analyse intra-correlation among nodes. We used network analysis to further examine the relationships among types of variables. Data were analysed using IBM Statistical Package for the Social Sciences version 25 and R version 3.5.0 (iGraph package version 1.2.5).

RESULTS

Categories of adverse events, root causes, and actions

Frequencies and percentages for identified categories of adverse events, root causes, and actions are reported in Supplement A alongside scores for degree, betweenness, and eigenvector.

In total, 499 adverse events were identified and classified under six major themes. The three most frequently reported events concerned cooperation, evaluation, and continuity. 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 23 % of cases involving follow-up, healthcare planning that could have provided a framework for treatment during the transition was also lacking.

In line with the structure of the RCA protocol, contributing root causes formed five major themes (Supplement A). The most frequently reported root causes concerned poor compliance to existing guidelines (23 %), lack of guidelines that could be applied in a specific context (12 %) and lack of available resources (10 %).

In total, 700 recommended actions were identified (Supplement A). The most frequently reported actions concerned changes in routines ($n = 403$) or improvements in staff education ($n = 103$). Thirty-seven reports were related to changes in equipment or in the physical environment. In 51 reports, the healthcare provider suggested an action that was unclear or did not involve any actual changes. These were excluded from the final total but are displayed in the plotted network to illustrate covariance with other variables.

Nodes and links

Figure 1 shows the 25 nodes connected in the network of major events, root causes, and recommended actions.

[PLEASE INSERT FIGURE 1 HERE]

Network analysis statistics are shown in Table 2. The graph metrics for our material show a well-connected network, with short distances between the most distal nodes. The variety in degree, betweenness and eigenvector scores indicate that while some nodes are highly connected and play a role as bridge to other nodes, some are satellites and are less significant for the entire network.

Table 2. Statistical description of major themes

Type of network	Number of themes	Mean degree	Degree centrality, range	Betweenness centrality, range	Eigenvector centrality, range
Major themes network	25	6.64	1–14	0–88	0.002–1.0

Central and peripheral nodes in the network

Node rankings are presented for degree centrality, betweenness, and eigenvector scores in Table 3.

High and low scores should be interpreted as how central or peripheral a node is in the network. Top ranked nodes represent discontinued or deficient treatment due to failed routines or ill-defined responsibilities. Low ranked nodes represent occasional failures such as missed screenings for possession of weapons, risk of violence, or need of extra monitoring. Among the lowest ranked nodes are also absent/insufficient interactions with relatives and cases in which the patient declined further contact.

Table 3. Top and bottom ranked values of degree, betweenness, and eigenvector. Colour coding: yellow = actions; green = adverse events, pink = root causes

A full list of ranked values of degree, betweenness, and eigenvector is provided in Supplement B.

RANK	Node ID	Description	Degree score	Node ID	Description	Betweenness score	Node ID	Description	Eigenvector score
1	ACT8	Structural changes in procedures	23	ACT8	Structural changes in procedures	128.67	AE10	Deficiencies related to staffing, etc.	1
2	AE10	Deficiencies related to staffing, etc.	20	AE2	Incomplete assessment of mental condition	77.17	AE12	Treatment not scheduled	0.97
3	AE12	Treatment not scheduled	19	RC6	Suboptimal work structure	73.17	ACT8	Structural changes in procedures	0.89
4	RC16	Lack of competence regarding documentation	17	AE1	Incomplete assessment of suicide risk	68.5	RC5	Discontinuity issues	0.71
5	AE2	Incomplete assessment of mental condition	15	RC16	Lack of competence regarding documentation	66.58	RC4	Routine matters, others	0.67
44	AE4	Incomplete screening for need of extra monitoring	3	AE4	Incomplete screening for need of extra monitoring	0	RC10	Insufficient communication with patients or relatives	0.1
45	AE11	Patient declined contact	2	AE5	Incomplete screening for possession of weapons	0	RC15	Lack of competence regarding documentation	0.06

46	ACT9	Alteration in patient rooms at ward	2	AE11	Patient declined contact	0	AE3	Incomplete screening for risk of violence	0.04
47	AE3	Incomplete screening for risk of violence	1	AE17	Absent/insufficient interaction with relatives	0	ACT9	Alteration in patient rooms at ward	0.04
48	AE5	Incomplete screening for possession of weapons	1	RC11	Suboptimal internal communication	0	AE5	Incomplete screening for possession of weapons	0.02

Detected clusters

Cluster analysis of the major theme network based on leading eigenvectors yielded four clusters (Figure 2 and Table 4).

The largest cluster (red) represents errors that occurred between patient and caregiver, such as missed assessments or deficiencies in documentation. It is dominated by the sentinel node (A) representing evaluation.

[PLEASE INSERT FIGURE 2 HERE]

The cluster with the second largest number of connections (blue) is characterized by shortcomings in internal teamwork, also shown by the sentinel node (C) of the cluster. Recommended actions are directed towards optimizing resources and improving cooperation on an organizational level. The blue cluster also contains 30 cases in which the RCA team reported a need for further investigation.

Table 4. Specification of nodes, shown cluster-wise. Sentinel nodes in bold.

RED CLUSTER n = 857							
Node ID	Type	Specification	n	Betweenness	Degree	n × B × D ¹	
G	RC	Procedures, routines, and policies	224	16	13	46,592	
A	AE	Evaluation	149	19.5	12	34,866	
I	RC	Communication and information issues	68	17	8	9248	
E	AE	Documentation	78	14.5	7	7917	
X	ACT	Educate co-workers	76	7	6	3192	
Q	ACT	New routine	102	1	9	918	
F	AE	Relatives	6	1	4	24	
O	ACT	Information to co-workers	94	0	3	0	
V	ACT	Update existing routine documents	60	0	3	0	
BLUE CLUSTER n = 415							
S	ACT	Structural changes in procedures	157	88	14	193,424	

¹ The combined score of frequency, betweenness and degree.

C	AE	Cooperation	86	16.5	8	11,352
H	RC	Organizational issues	93	7.5	11	7673
R	ACT	Optimize staffing	46	7.5	8	2760
Z	ACT	Increase number of inpatient beds	3	6	5	90
Y	ACT	Further investigation needed	30	0	3	0
PURPLE CLUSTER n = 361						
D	AE	Follow-up, continuity, and planning	171	12	10	20,520
M	ACT	Further implementation of existing routine	84	26.5	8	17808
J	RC	Competence and education	62	8	10	4960
L	ACT	Clarifying and defining responsibilities between two units	27	1.5	6	243
N	ACT	Better information to patients and/or relatives	17	0	5	0
GREEN CLUSTER n = 79						
P	ACT	No/unclear action	21	28.5	4	2394
B	AE	Safety issues	9	43	3	1161
K	RC	Technical equipment and systems	15	23.5	3	1058
U	ACT	Update hardware or software	23	0	2	0
T	ACT	Alteration of patient rooms at ward	11	0	1	0

A somewhat smaller cluster (purple) involves issues that occurred at the interface between two units. The sentinel node (D) represents follow-up, continuity, and healthcare planning. The actions are focused on clarifying responsibilities, but also on enhancing knowledge and providing better information to patients and relatives.

The smallest cluster (green) is dominated by safety concerns. It holds the fewest number of adverse events, root causes, and actions and includes the 21 cases in which the RCA team did not recommend any clear action.

Centralized in the network are nodes representing failed routines and suboptimal work structures (G, M, Q, and S); organizational issues and staffing (H and R); discontinued treatment (D); deficient internal and external cooperation (C); and lack of adequate competence among co-workers (J, X). Six of those nodes (C, H, J, M, S, and X) are located at the intersection between two clusters.

DISCUSSION

The results show four patient safety domains in suicide prevention where errors may occur: (1) between patient and caregiver, (2) among co-workers in the same unit, (3) at the interface between two or more units, and (4) failed safety procedures at inpatient services. Each domain is dominated by areas of particular importance: (1) evaluation, (2) cooperation, organizational issues, structural changes in procedures, and staff optimization, (3) follow-up, continuity, and planning, and (4) safety issues.

The largest (red) cluster was dominated by the sentinel node representing evaluation. Previous RCA studies have pointed out evaluation as a salient feature, highlighting limited access to adequate assessments as a main risk factor in suicide prevention. To correct this deficiency, healthcare teams must be organized in efficient, cooperative units to ensure that suicidal patients not only receive the most immediate care at the emergency ward, but also are followed up appropriately after discharge.[32, 36]

Issues involving local structures and procedures were central features of our network analysis. This could be an artefact of the RCA framework, which regards a unit's level of patient safety as a reflection of its policies. We note, however, that similar features were identified in a previous Swedish study[37] in which only one quarter of the audits were RCA reports (E. Roos af Hjelmsäter, personal communication, 9 September 2020). This suggests that the large number of deficiencies related to routines may capture real problems in large organizational units.

The smallest (green) cluster contains 79 reported issues concerning safety aspects, technical equipment, and environmental conditions such as the design of patient rooms. Actions directed towards this area have the potential to be more stable and permanent; removed ligature points do not suddenly reappear. This contrasts with recommended actions in the other clusters, which often involve time-consuming new or improved routines that may be difficult to sustain.

Since the larger clusters more often involve multi-unit organizational factors than the smaller, more isolated clusters, it is reasonable to look beyond single deficiencies when planning future remedial interventions. Such interventions would probably also benefit from being adjusted according to the type of network and cluster the identified deficiency belongs to. For example, deficiencies in the red, blue, and purple clusters are often tied to shared responsibilities, cooperation, and communication. These are highly dependent on other factors such as social dynamics and choice of implementation strategy, and they require extensive effort to achieve fundamental change, whereas those located in

1
2
3 the green cluster are contained within a single unit, facilitating a more straightforward
4 implementation.[44-46]
5

6
7 Nodes within the same cluster tend to co-exist, which implies that events would benefit from being
8 investigated cluster wise. The connectivity of the network also suggests a possibility that adverse
9 events in one area may be a consequence of deficiencies in another area. Providing suicidal patients
10 with safe interventions, for instance, depends not only on the personal conditions of the evaluating
11 clinician and the patient being assessed, but also on proper work structures, well-educated teams,
12 good intrateam communication, sufficient documentation, and – perhaps most of all – effective and
13
14
15
16
17 trusting partnerships with patients and their relatives.
18

19 20 **CONCLUSION**

21 Applying network analysis to occurrences and adverse events in complex healthcare systems can
22 elucidate patterns of associated factors and contribute to a better understanding of the mechanisms
23 involved. Ecological studies on the local conditions within a unit affecting, or affected by, these
24 factors may provide additional information about stability, resilience, and sources of risk in suicide
25 prevention and other healthcare interventions.
26
27
28
29

30 31 **STRENGTHS AND LIMITATIONS**

32 To our knowledge, this is the first network study of data gleaned from post-suicide audits. Strengths
33 of the study include data collected from NITHA, the only open national resource in Sweden for the
34 dissemination of RCA reports. These reports were produced in a standardized manner by trained RCA
35 teams, and the data were examined and categorized by four professionals, all experienced in
36 performing and peer-reviewing RCAs.
37
38
39
40

41 The study also has several limitations. Since we obtained our data exclusively through the NITHA
42 system, other post-suicide investigations were not included. Because regional institutional praxis
43 concerning submission to the NITHA database varies, RCA reports cannot be considered
44 representative for the country of Sweden. A relatively small proportion of all suicides were submitted
45 to the database, and therefore selection bias cannot be ruled out. Moreover, since the RCA method
46 aims to identify organizational vulnerabilities, the reports lack certain details concerning the patients
47 themselves. Furthermore, the classification tool used by the auditing teams has not been validated
48 by independent reviewers. The data was qualitatively categorized and could have been organized
49 differently.
50
51
52
53
54
55
56
57
58
59
60

FUTURE RESEARCH

Given the innovative methodology used in this study, in-depth exploration of each cluster is required. We also suggest further studies on the longitudinal effects of actions taken and network analyses of real-world healthcare systems. Because RCAs include no follow-up information on whether recommended actions were implemented, this could also be a topic for further study using a different type of approach.

ACKNOWLEDGEMENTS

The authors would like to express their gratitude towards Cecilia Boldt-Christmas, Marzia Dellepiane, and Evalena von Hausswolff who participated in the data collection.

CONTRIBUTORS

MR designed the study, collected and registered the data, performed the analyses, and drafted the manuscript. EC, LA, MW, and TB contributed to the study design, analyses, and manuscript revision. All authors read and approved the final manuscript.

COMPETING INTERESTS

There are no competing interests for any author

FUNDING

This work was supported by the Affective Clinic, Sahlgrenska University Hospital, Gothenburg, Region Västra Götaland (no specific grant number).

DATA AVAILABILITY STATEMENT

Data are available upon reasonable request.

PATIENT AND PUBLIC INVOLVEMENT

Neither patients nor the public were involved in this study.

ETHICAL REVIEW

According to the Swedish Act Concerning the Ethical Review of Research Involving Humans (2003:460), this study did not require ethical review as it did not involve human participants.

REFERENCES

1. World Health Organization. Preventing suicide: a global imperative. 2014.
2. Ropper AH, Fazel S, Runeson B. Suicide. *The New England Journal of Medicine*. 2020;382(3):266-74.
3. Too LS, Spittal MJ, Bugeja L, et al. The association between mental disorders and suicide: A systematic review and meta-analysis of record linkage studies. *Journal of Affective Disorders*. 2019;259:302-13.
4. Large M, Sharma S, Cannon E, et al. Risk Factors for Suicide Within a Year of Discharge from Psychiatric Hospital: A Systematic Meta-Analysis. *Australian & New Zealand Journal of Psychiatry*. 2011;45(8):619-28.
5. Waern M, Kaiser N, Renberg ES. Psychiatrists' experiences of suicide assessment. *BMC Psychiatry, 2016, Vol 16*. 2016;16.
6. Steeg S, Quinlivan L, Nowland R, et al. Accuracy of risk scales for predicting repeat self-harm and suicide: a multicentre, population-level cohort study using routine clinical data.(Report). *BMC Psychiatry*. 2018;18(1).
7. Smith MJ, Bouch J, Bradstreet S, et al. Health services, suicide, and self-harm: patient distress and system anxiety. *The lancet Psychiatry*. 2015;2(3):275-80.
8. Cheng A, Chen T, Chen CC, et al. Psychosocial and psychiatric risk factors for suicide: case-control psychological autopsy study. *British Journal of Psychiatry*. 2000(177):360-5.
9. Berman AL, Silverman MM. Suicide Risk Assessment and Risk Formulation Part II : Suicide Risk Formulation and the Determination of Levels of Risk. *Suicide and Life-Threatening Behavior*. 2014;44(4):432-43.
10. Pirkis J, Too LS, Spittal MJ, et al. Interventions to reduce suicides at suicide hotspots: a systematic review and meta-analysis. *The lancet Psychiatry*. 2015;2(11):994-1001.

11. Barker E, Kolves K, De Leo D. Rail-suicide prevention: Systematic literature review of evidence-based activities. *Asia-Pacific Psychiatry*. 2017;9(3):e12246.
12. Zalsman G, Hawton K, Wasserman D, et al. Suicide prevention strategies revisited: 10-year systematic review. *The lancet Psychiatry*. 2016;3(7):646-59.
13. Zalsman G, Hawton K, Wasserman D, et al. Evidence-based national suicide prevention taskforce in Europe: A consensus position paper. *European Neuropsychopharmacology*. 2017;27(4):418-21.
14. Mann JJ, Apter A, Bertolote J, et al. Suicide prevention strategies: a systematic review. *Jama*. 2005;294(16):2064-74.
15. Meerwijk EL, Parekh A, Oquendo MA, et al. Direct versus indirect psychosocial and behavioural interventions to prevent suicide and suicide attempts: a systematic review and meta-analysis. *The lancet Psychiatry*. 2016;3(6):544-54.
16. Sakashita T, Oyama H. Overview of community-based studies of depression screening interventions among the elderly population in Japan. *Aging & mental health*. 2016;20(2):231-9.
17. Burgess P, Pirkis J, Morton J, et al. Lessons From a Comprehensive Clinical Audit of Users of Psychiatric Services Who Committed Suicide. *Psychiatric Services*. 2000;51(12):1555-60.
18. Large M, Smith G, Sharma S, et al. Systematic review and meta-analysis of the clinical factors associated with the suicide of psychiatric in-patients. *Acta Psychiatrica Scandinavica*. 2011;124(1):18-9.
19. Meehan J, Kapur N, Hunt I, et al. Suicide in Mental Health In-Patients and within 3 Months of Discharge. *The British Journal of Psychiatry*. 2006;188(2):129-34.
20. Iliachenko EK, Ragazan DC, Eberhard J, et al. Suicide mortality after discharge from inpatient care for bipolar disorder: A 14-year Swedish national registry study. *Journal of psychiatric research*. 2020;127:20-7.

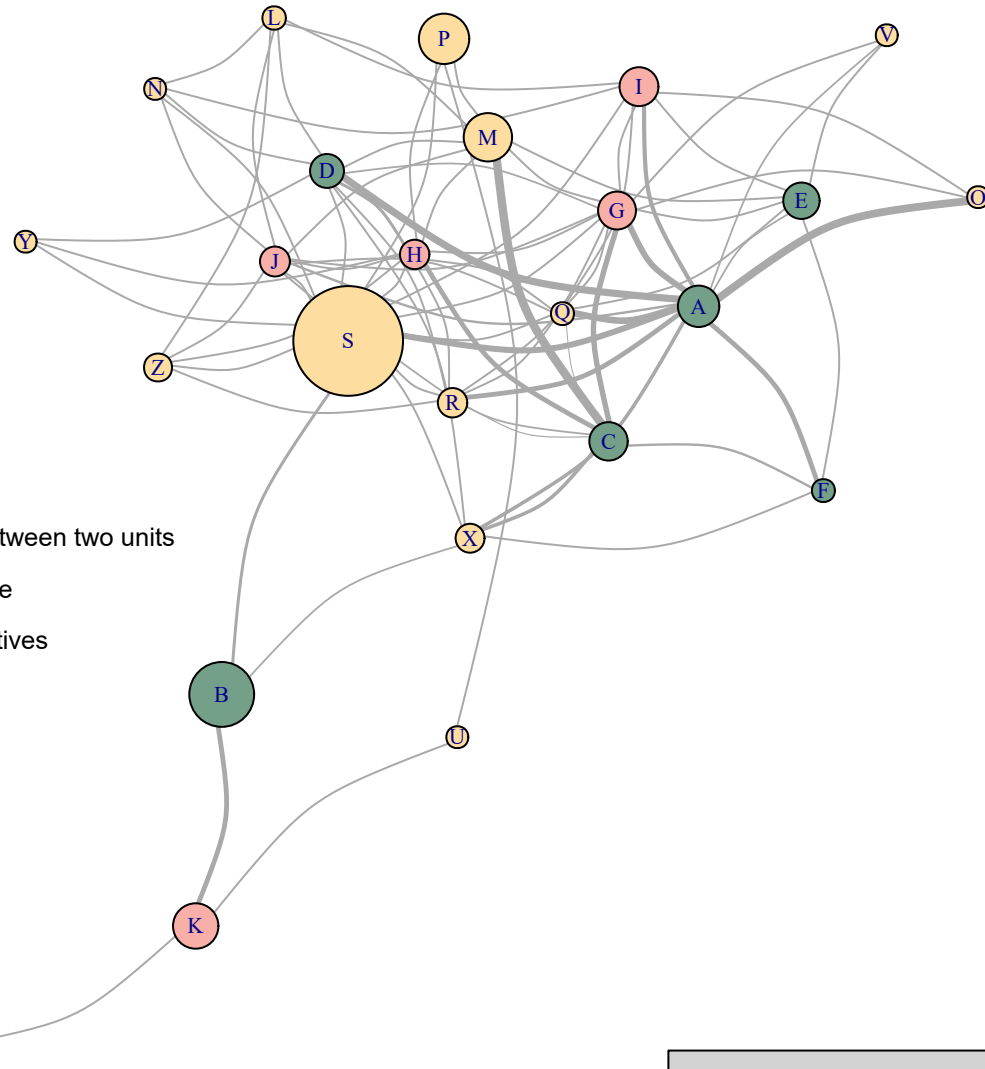
- 1
2
3
4 21. Haglund A, Lysell H, Larsson H, et al. Suicide Immediately After
5 Discharge From Psychiatric Inpatient Care: A Cohort Study of Nearly 2.9
6 Million Discharges. *The Journal of clinical psychiatry*. 2019;80(2).
7
8
- 9 22. Appleby L, Dennehy JA, Thomas CS, et al. Aftercare and clinical
10 characteristics of people with mental illness who commit suicide: a case-
11 control study. *The Lancet*. 1999;353(9162):1397-400.
12
13
- 14 23. Qin P, Nordentoft M. Suicide Risk in Relation to Psychiatric
15 Hospitalization: Evidence Based on Longitudinal Registers. *JAMA psychiatry*.
16 2005;62(4):427-32.
17
18
- 19 24. Chung D, Hadzi-Pavlovic D, Wang M, et al. Meta-analysis of
20 suicide rates in the first week and the first month after psychiatric
21 hospitalisation. *BMJ Open*. 2019;9(3).
22
23
- 24 25. Riblet VN, Shiner RB, Watts RB, et al. Death by Suicide Within 1
25 Week of Hospital Discharge: A Retrospective Study of Root Cause Analysis
26 Reports. *The Journal of Nervous and Mental Disease*. 2017;205(6):436-42.
27
28
- 29 26. Valenstein M, Kim HM, Ganoczy D, et al. Higher-risk periods for
30 suicide among VA patients receiving depression treatment: Prioritizing suicide
31 prevention efforts. *Journal of Affective Disorders*. 2009;112(1):50-8.
32
33
- 34 27. Bickley H, Hunt IM, Windfuhr K, et al. Suicide Within Two Weeks of
35 Discharge From Psychiatric Inpatient Care: A Case-Control Study. *Psychiatric
36 Services*. 2013;64(7):653-9.
37
38
- 39 28. Hoffmire C, Stephens B, Morley S, et al. VA Suicide Prevention
40 Applications Network:A National Health Care System–Based Suicide Event
41 Tracking System. *Public Health Reports*. 2016;131(6):816-21.
42
43
- 44 29. Clarke I. Learning from critical incidents. *Advances in Psychiatric
45 Treatment*. 2018;14(6):460-8.
46
47
- 48 30. Swedish Association of Local Authorities and Regions.
49 Händelseanalys & riskanalys handbok för patientsäkerhetsarbete. Stockholm:
50 Stockholm : Sveriges kommuner och landsting; 2005.
51
52
53
54
55
56
57
58
59
60

- 1
2
3
4 31. Mills PD, Gallimore BI, Watts BV, et al. Suicide attempts and
5 completions in Veterans Affairs nursing home care units and long-term care
6 facilities: a review of root-cause analysis reports. *International Journal of*
7 *Geriatric Psychiatry*. 2016;31(5):518-25.
- 8
9
10
11 32. Mills PD, Huber SJ, Vince Watts B, et al. Systemic vulnerabilities to
12 suicide among veterans from the Iraq and Afghanistan Conflicts: review of
13 case reports from a National Veterans Affairs Database. *Suicide Life Threat*
14 *Behav*. 2011;41(1):21-32.
- 15
16
17
18 33. Mills PD, Neily J, Luan D, et al. Actions and implementation
19 strategies to reduce suicidal events in the Veterans Health Administration. *Jt*
20 *Comm J Qual Patient Saf*. 2006;32(3):130-41.
- 21
22
23
24 34. Aboumrad M, Shiner B, Riblet N, et al. Factors contributing to
25 cancer-related suicide: A study of root-cause analysis reports.
26 *Psychooncology*. 2018;27(9):2237-44.
- 27
28
29
30 35. Mills PD, Watts BV, Shiner B, et al. Adverse events occurring on
31 mental health units. *General Hospital Psychiatry*. 2018;50:63-8.
- 32
33
34 36. Gillies D, Chicop D, O'Halloran P. Root Cause Analyses of
35 Suicides of Mental Health Clients. *Crisis: The Journal of Crisis Intervention*
36 *and Suicide Prevention*. 2015;36(5):316-24.
- 37
38
39
40 37. Roos af Hjelmsäter E, Ros A, Gäre BA, et al. Deficiencies in
41 healthcare prior to suicide and actions to deal with them: a retrospective study
42 of investigations after suicide in Swedish healthcare. *BMJ Open*.
43 2019;9(12):e032290.
- 44
45
46
47 38. Caiani M. Social Network Analysis: Oxford University Press; 2014.
- 48
49 39. Luke DA, Dhand A, Carothers BJ. Social Network Analysis: Oxford
50 University Press; 2017.
- 51
52
53 40. Pow J, Gayen K, Elliott L, et al. Understanding complex
54 interactions using social network analysis. *Journal of clinical nursing*.
55 2012;21(19-20):2772.
- 56
57
58
59
60

- 1
2
3
4 41. Luke DA, Harris JK. Network analysis in public health: history,
5 methods, and applications. *Annual review of public health*. 2007;28:69.
6
7 42. Luke DA, Harris JK. Network Analysis in Public Health: History,
8 Methods, and Applications. *Annual Review of Public Health*. 2007;28(1):69-93.
9
10 43. Hansen DL, Shneiderman B, Smith MA, et al. Chapter 6 -
11 Calculating and visualizing network metrics. In: Hansen DL, Shneiderman B,
12 Smith MA, Himmelboim I, editors. *Analyzing Social Media Networks with*
13 *NodeXL (Second Edition)*: Morgan Kaufmann; 2020. p. 79-94.
14
15 44. Wolf A, Carlström E. *Förutsättningar för omställning till*
16 *personcentrerad vård - ledarskap, medarbetarskap och organisation*. Liber
17 Stockholm; 2014. p. 113-26.
18
19 45. Greenhalgh T, Robert G, Macfarlane F, et al. Diffusion of
20 innovations in service organizations: systematic review and recommendations.
21 *The Milbank quarterly*. 2004;82(4):581-629.
22
23 46. Carlström ED, Ekman I. Organisational culture and change:
24 implementing person-centred care. *Journal of Health Organization and*
25 *Management*. 2012;26(2):175-91.
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Network of major adverse events, major root causes, and planned actions

- 1
- 2
- 3 A Evaluation
- 4
- 5 B Safety issues
- 6
- 7 C Cooperation
- 8
- 9 D Follow up, continuity, and planning
- 10
- 11 E Documentation
- 12
- 13 F Relatives
- 14
- 15 G Procedures, routines, and policies
- 16
- 17 H Organizational issues
- 18
- 19 I Communication and information issues
- 20
- 21 J Competence and education
- 22
- 23 K Technical equipment and systems
- 24
- 25 L Clarifying and defining responsibilities between two units
- 26
- 27 M Further implementation of existing routine
- 28
- 29 N Better information to patients or/and relatives
- 30
- 31 O Information to co-workers
- 32
- 33 P No/unclear action
- 34
- 35 Q New routine
- 36
- 37 R Optimize staffing
- 38
- 39 S Structural changes in procedures
- 40
- 41 T Alteration of patient rooms at ward
- 42
- 43 U Update hardware or software
- 44
- 45 V Update existing routine documents
- 46
- 47
- 48
- 49
- 50
- 51
- 52
- 53
- 54
- 55
- 56
- 57
- 58
- 59
- 60
- 61
- 62
- 63
- 64
- 65
- 66
- 67
- 68
- 69
- 70
- 71
- 72
- 73
- 74
- 75
- 76
- 77
- 78
- 79
- 80
- 81
- 82
- 83
- 84
- 85
- 86
- 87
- 88
- 89
- 90
- 91
- 92
- 93
- 94
- 95
- 96
- 97
- 98
- 99
- 100
- 101
- 102
- 103
- 104
- 105
- 106
- 107
- 108
- 109
- 110
- 111
- 112
- 113
- 114
- 115
- 116
- 117
- 118
- 119
- 120
- 121
- 122
- 123
- 124
- 125
- 126
- 127
- 128
- 129
- 130
- 131
- 132
- 133
- 134
- 135
- 136
- 137
- 138
- 139
- 140
- 141
- 142
- 143
- 144
- 145
- 146
- 147
- 148
- 149
- 150
- 151
- 152
- 153
- 154
- 155
- 156
- 157
- 158
- 159
- 160
- 161
- 162
- 163
- 164
- 165
- 166
- 167
- 168
- 169
- 170
- 171
- 172
- 173
- 174
- 175
- 176
- 177
- 178
- 179
- 180
- 181
- 182
- 183
- 184
- 185
- 186
- 187
- 188
- 189
- 190
- 191
- 192
- 193
- 194
- 195
- 196
- 197
- 198
- 199
- 200
- 201
- 202
- 203
- 204
- 205
- 206
- 207
- 208
- 209
- 210
- 211
- 212
- 213
- 214
- 215
- 216
- 217
- 218
- 219
- 220
- 221
- 222
- 223
- 224
- 225
- 226
- 227
- 228
- 229
- 230
- 231
- 232
- 233
- 234
- 235
- 236
- 237
- 238
- 239
- 240
- 241
- 242
- 243
- 244
- 245
- 246
- 247
- 248
- 249
- 250
- 251
- 252
- 253
- 254
- 255
- 256
- 257
- 258
- 259
- 260
- 261
- 262
- 263
- 264
- 265
- 266
- 267
- 268
- 269
- 270
- 271
- 272
- 273
- 274
- 275
- 276
- 277
- 278
- 279
- 280
- 281
- 282
- 283
- 284
- 285
- 286
- 287
- 288
- 289
- 290
- 291
- 292
- 293
- 294
- 295
- 296
- 297
- 298
- 299
- 300

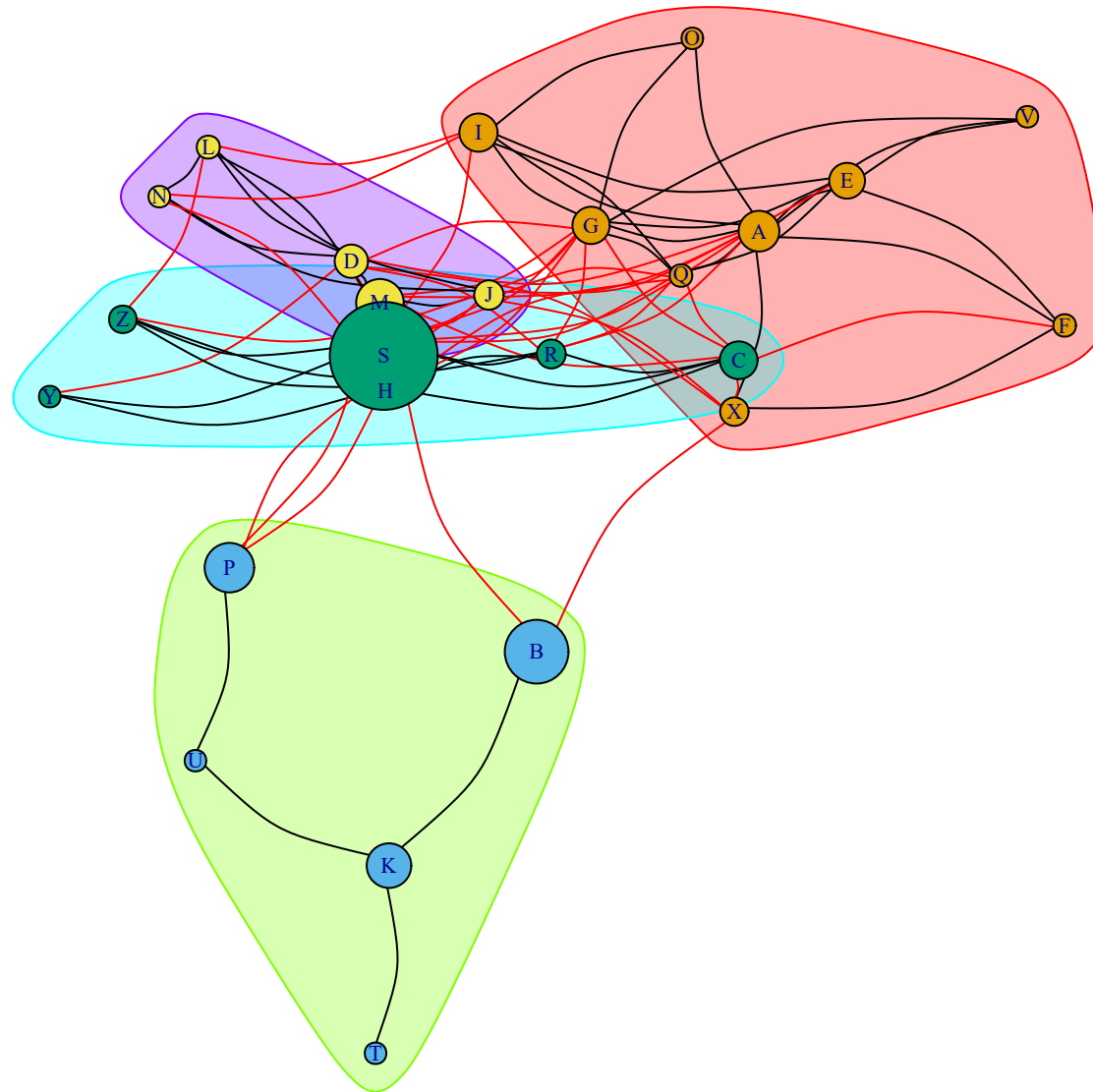


■	Adverse events
■	Root causes
■	Actions

For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

Size of nodes corresponds to traffic through the node

- 1
- 2
- 3 RED CLUSTER n = 857
- 4 A AE - Evaluation
- 5 E AE - Documentation
- 6 F AE - Relatives
- 7 G RC - Procedures, routines, and policies
- 8
- 9 RC - Communication and information issues
- 10 I ACT - Information to co-workers
- 11 Q ACT - New routine
- 12 V ACT - Update existing routine documents
- 13 X ACT - Educate co-workers
- 14
- 15
- 16
- 17 BLUE CLUSTER n = 415
- 18 C AE - Cooperation
- 19 H RC - Organizational issues
- 20 J ACT - Optimize staffing
- 21 S ACT - Structural changes in procedures
- 22 Z ACT - Further investigation needed
- 23 A ACT - Increase number of inpatient beds
- 24
- 25
- 26
- 27
- 28 PURPLE CLUSTER n = 361
- 29 L AE - Follow up, continuity, and planning
- 30 N RC - Competence and education
- 31 D ACT - Clarifying and defining responsibilities between two units
- 32 M ACT - Further implementation of existing routine
- 33 J ACT - Better information to patients or/and relatives
- 34
- 35
- 36
- 37 GREEN CLUSTER n = 79
- 38
- 39 S AE - Safety issues
- 40 R RC - Technical equipment and systems
- 41 I ACT - No/unclear action
- 42 T ACT - Alteration of patient rooms at ward
- 43 U ACT - Update hardware or software
- 44
- 45
- 46



1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Adverse events n=499					Root causes n = 462					Actions n = 700													
Node ID	Major theme	Description	Subtheme	Frequencies n (%)	Drugs	Betweenness	Eigenvector	Node ID	Major theme	Subtheme	Frequencies n (%)	Drugs	Betweenness	Eigenvector	Node ID	Theme	Description	Frequencies n (%)	Drugs	Betweenness	Eigenvector		
D	Follow-up, continuity, and planning (n = 372)	Planning medical and non-medical treatment, health care, related problems and continuity issues	Treatment not scheduled	72 (14 %)	19	0.2	0.07	G	Procedures, routines, and policies (n = 238)	Lack of discipline in existing routine	107 (23 %)	14	0.33	0.52	S	Structural changes in procedures	Structural changes	127 (22%)	23	0.67	0.88		
			Deficiencies in staffing, etc.	40 (8 %)	12	0.25	0.49			Q	New routine (n = 102)	Introducing a new routine	102 (15%)	12	0.1	0.12							
			No follow-up provided by main caregiver	17 (3 %)	11	0.1	0.54			O	Information to coworkers (n = 94)	Information to coworkers	94 (13%)	8	0.24	0.21							
A	Evaluation (n = 148)	Evaluating and assessing general of overall state and suicide risk	Suboptimal assessment of suicide risk	77 (15 %)	12	0.65	0.38	H	Organizational issues (n = 95)	Suboptimal work structure	22 (5 %)	14	0.33	0.71	M	Further implementation of existing routine (n = 84)	Implementation of already existing routine	84 (12%)	13	0.45	0.63		
			Lack of available resources	73 (14 %)	15	0.73	0.55			V	Update existing routine	Update existing routine	60 (9%)	5	0.1	0.11							
C	Cooperation (n = 84)	External or internal cooperation and changes of shared resources such as staffing, hardware, software, or space	Unclear definition of responsibility	79 (16 %)	9	0.67	0.28	I	Communication and information (n = 48)	Suboptimal communication in internal unit	28 (6 %)	11	0.27	0.43	R	Educate coworkers (n = 76)	Improving education	76 (11%)	11	0.88	0.35		
			Suboptimal internal	7 (1 %)	5	0.5	0.16			U	Updating hardware or software (n = 25)	Updating hardware or software	25 (4%)	5	0.16	0.16							
E	Documentation (n = 78)	Shortfalling, discrepancies in documentation and transfer of information	Assessment not recorded	41 (8 %)	12	0.25	0.36	J	Competence and education (n = 41)	Suboptimal communication in patient or patient's family	10 (2 %)	5	0.5	0.1	N	Improving information patient and relatives (n = 17)	Making changes in information from the patient or relatives	17 (2%)	13	0.27	0.51		
			Suboptimal transfer of information	37 (7 %)	5	0.75	0.14			T	Altering patient rooms on the ward (n = 11)	Altering patient rooms on the ward	11 (2%)	2	0.04	0.04							
B	Safety issues (n = 78)	Assessing risk of violence, need for extra monitoring, or possession of weapons, confiscation of means of suicide	Incomplete screening of means of suicide	2 (0.4 %)	7	0.03	0.27	K	Technical equipment and systems (n = 15)	Communication, other	3 (0.7 %)	8	0.55	0.28	not included in total	Y	ICT11	Further investigation needed	30	0	0.5	0.4	
			Incomplete screening for risk of violence	3 (0.6 %)	1	0	0.04			not included in total	P	ACT5	No/unclear action	21	8	0.1	0.11						
			Incomplete screening of need for extra monitoring	2 (0.4 %)	3	0	0.12			not included in total													
F	Relatives (n = 4)	Engaging relatives in the patient's care	Incomplete screening for use of drugs	1 (0.2 %)	4	1	0.38			Competence, basic, others	12 (2 %)	17	0.58	0.6									
			Nonrecognition of interaction with relatives	0 (0 %)	0	0	0.13			Suboptimal design of devices or systems	15 (3 %)	5	2	0.14									

For peer review only

RANK	Node ID	Description	Degree score	Node ID	Description	Betweenness score	Node ID	Description	Eigenvector score
1	ACT8	Structural changes in procedures	23	ACT8	Structural changes in procedures	128.67	AE10	Deficiencies related to staffing, etc.	1
2	AE10	Deficiencies related to staffing, etc.	20	AE2	Incomplete assessment of mental condition	77.17	AE12	Treatment not scheduled	0.97
3	AE12	Treatment not scheduled	19	RC6	Suboptimal work structure	73.17	ACT8	Structural changes in procedures	0.89
4	RC16	Lack of competence regarding documentation	17	AE1	Incomplete assessment of suicide risk	68.5	RC5	Discontinuity issues	0.71
5	AE2	Incomplete assessment of mental condition	15	RC16	Lack of competence regarding documentation	66.58	RC4	Routine matters, other	0.67
6	RC2	Lack of applicable routine	15	AE12	Treatment not scheduled	62	RC13	Lack of competence regarding medical condition or level of risk	0.64
7	RC4	Routine matters, others	15	AE15	Assessment not recorded	59.25	RC2	Lack of applicable routine	0.63
8	RC6	Suboptimal work structure	15	RC7	Lack of available resources	56.25	ACT2	Further implementation of existing routine	0.63
9	RC1	Lack of compliance to existing routine	14	AE8	Unclear definition of responsibility	55.67	RC16	Lack of competence regarding documentation	0.6
10	RC5	Discontinuity issues	14	AE14	Deficiencies related to healthcare plan	51.25	ACT7	Optimizing staffing	0.59
11	RC13	Lack of competence regarding medical condition or level of risk	14	RC1	Lack of compliance to existing routine	45.33	RC6	Suboptimal work structure	0.59
12	ACT2	Further implementation of existing routine	13	RC2	Lack of applicable routine	41.33	AE2	Incomplete assessment of mental condition	0.55
13	ACT3	Better information to patients or/and relatives	13	RC4	Routine matters, others	39	AE13	No follow up provided by next caregiver	0.54
14	ACT7	Optimize staffing	13	ACT12	Educating coworkers	38.83	ACT3	Better information to patients or/and relatives	0.53
15	AE1	Incomplete assessment of suicide risk	12	ACT7	Optimizing staffing	36.5	RC1	Lack of compliance to existing routine	0.52
16	AE14	Deficiencies related to healthcare plan	12	ACT2	Further implementation of existing routine	34.5	ACT6	New routine	0.52
17	AE15	Assessment not recorded	12	RC12	Communication, other	33.5	AE14	Deficiencies related to healthcare plan	0.49
18	RC7	Lack of available resources	12	RC3	Existing routine is incomplete	28.83	RC7	Lack of available resources	0.47
19	ACT6	New routine	12	RC8	Suboptimal communication w. external unit	27	RC8	Suboptimal communication w. external unit	0.43
20	AE13	No follow-up provided by next caregiver	11	ACT3	Better information to patients or/and relatives	27	ACT1	Clarifying and defining responsibilities between two units	0.42
21	RC8	Suboptimal communication w. external unit	11	ACT4	Information to coworkers	24.5	ACT13	Further investigation	0.4
22	ACT12	Education of coworkers	11	AE10	Deficiencies related to staffing etc.	23.92	AE1	Incomplete assessment of suicide risk	0.38
23	AE8	Unclear definition of responsibilities	9	ACT13	Further investigation	19.5	AE15	Assessment not recorded	0.36
24	RC3	Existing routine is incomplete	9	RC13	Lack of competence regarding medical condition or level of risk	17	ACT12	Educating coworkers	0.35
25	ACT1	Clarifying and defining responsibilities between different units	9	AE6	Incomplete screening of means of suicide	14.33	AE7	Incomplete screening for use of drugs	0.33
26	ACT13	Further investigation	9	ACT14	ACT14	14	RC11	Suboptimal internal communication	0.32
27	RC12	Communication, other	8	RC5	Discontinuity issues	13.33	ACT5	No/unclear action	0.31

28	RC14	Lack of competence regarding juridical or organizational matters	8	AE16	Suboptimal transfer of information	10.75	ACT14	Increase in inpatient beds	0.31
29	ACT4	Information to coworkers	8	RC14	Lack of competence regarding juridical or organizational matters	10.33	RC3	Existing routine incomplete	0.3
30	ACT5	No/unclear action	8	RC15	Lack of competence regarding documentation	10	AE8	Unclear definition of responsibility	0.28
31	AE6	Incomplete screening of means of suicide	7	ACT11	Update existing routine documents	9	RC12	Communication, other	0.28
32	ACT14	Increase in inpatient beds	7	AE13	No follow up provided by next caregiver	8	RC14	Lack of competence regarding juridical or organizational matters	0.28
33	AE7	Incomplete screening for use of drugs	6	ACT6	New routine	8	AE6	Incomplete screening for means of suicide	0.27
34	RC9	Communication, administrative matters	6	RC10	Insufficient communication w. patients or relatives	7.5	AE11	Patient declined contact	0.22
35	RC11	Suboptimal internal communication	6	ACT1	Clarity responsibility and delimitation between two units	6	ACT4	Information to coworkers	0.21
36	AE9	Suboptimal internal cooperation	5	ACT5	No/unclear action	6	RC9	Communication, administrative matters	0.19
37	AE16	Suboptimal transfer of information	5	ACT10	Update hardware or software	5	AE9	Suboptimal internal cooperation	0.16
38	RC10	Insufficient communication w. patients or relatives	5	AE9	Suboptimal internal cooperation	3.5	ACT10	Updating hardware or software	0.16
39	RC17	Malfunctional design of devices or rooms	5	RC9	Communication, administrative matters	2	RC17	Malfunctional design of devices or rooms	0.14
40	ACT10	Updating hardware or software	5	RC17	Malfunctional design of devices or rooms	2	AE16	Suboptimal transfer of information	0.14
41	ACT11	Updating existing routine documents	5	ACT9	Alteration in patient rooms at ward	2	ACT11	Updating existing routine documents	0.13
42	AE17	Absent/insufficient interaction with relatives	4	AE7	Incomplete screening for use of drugs	1	AE17	Absent/insufficient interaction with relatives	0.13
43	RC15	Lack of competence regarding documentation	4	AE3	Incomplete screening for violence risk	0	AE4	Incomplete screening for need of extra monitoring	0.12
44	AE4	Incomplete screening for need of extra monitoring	3	AE4	Incomplete screening for need of extra monitoring	0	RC10	Insufficient communication w. patients or relatives	0.1
45	AE11	Patient declined contact	2	AE5	Incomplete screening for possession of weapons	0	RC15	Lack of competence regarding documentation	0.06
46	ACT9	Alteration in patient rooms on the ward	2	AE11	Patient has declined contact	0	AE3	Incomplete screening for risk of violence	0.04
47	AE3	Incomplete screening for risk of violence	1	AE17	Absent/insufficient interaction with relatives	0	ACT9	Alteration in patient rooms at ward	0.04
48	AE5	Incomplete screening for possession of weapons	1	RC11	Suboptimal internal communication	0	AE5	Incomplete screening for possession of weapons	0.02

BMJ Open

Coexisting service related factors preceding suicide: a network analysis

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2021-050953.R1
Article Type:	Original research
Date Submitted by the Author:	01-Nov-2021
Complete List of Authors:	Rex, Malin; University of Gothenburg, Institute of Health and Care Sciences, Sahlgrenska Academy; Sahlgrenska University Hospital, Affective clinic Brezicka, Thomas; Sahlgrenska University Hospital, Department for quality and patient safety Carlström, Eric; University of Gothenburg, Institute of Health and Care Sciences, Sahlgrenska Academy; University of Gothenburg, Centre for Person-Centred Care (GPCC) Waern, Margda; University of Gothenburg, Institute of Neuroscience and Physiology, Sahlgrenska Academy; Sahlgrenska University Hospital, Psychosis Clinic Ali, Lilas; University of Gothenburg, Institute of Health and Care Sciences, Sahlgrenska Academy; Sahlgrenska University Hospital, Affective Clinic
Primary Subject Heading:	Mental health
Secondary Subject Heading:	Mental health
Keywords:	Suicide & self-harm < PSYCHIATRY, PSYCHIATRY, Risk management < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Health & safety < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Organisational development < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Coexisting service related factors preceding suicide: a network analysis

Malin Rex^{1,2}, Thomas Brezicka⁴, Eric Carlström^{1,3}, Margda Waern^{5,6}, Lilas Ali^{1,2}.

¹ University of Gothenburg, Institute of Health and Care Sciences, Sahlgrenska Academy Gothenburg, Region Västra Götaland, Sweden

² Sahlgrenska University Hospital, Affective clinic Gothenburg, Region Västra Götaland, Sweden

³ University of Gothenburg, Centre for Person-Centred Care (GPCC) Gothenburg, Region Västra Götaland, Sweden

⁴ Sahlgrenska University Hospital, Department for quality and patient safety Gothenburg, Region Västra Götaland, Sweden

⁵ University of Gothenburg, Institute of Neuroscience and Physiology, Sahlgrenska Academy Gothenburg, Region Västra Götaland, Sweden

⁶ Sahlgrenska University Hospital, Psychosis Clinic Gothenburg, Region Västra Götaland, Sweden

Correspondence to: Malin Rex

POSTAL ADDRESS

University of Gothenburg, Institute of Health and Care Sciences
Box 457
405 30 Göteborg, Sweden

malin.rex@gu.se

+46-761199908

Keywords: Suicide, Patient safety, Network Analysis, Psychiatry, Mood disorders, Self-Injurious Behavior

ABSTRACT

Objectives

The overall objective of this paper 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 deficiencies in the network of major themes, along with the contributing factors representing organizational 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, no final conclusions could be drawn. Four communities were detected covering nodes for follow-up, evaluation, cooperation, and procedures; communication, documentation and organization; 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 organizational stability, in terms of work structure, resources and staffing, as a potential target for intervention, although this must be more extensively explored in the future.

SUMMARY - STRENGTHS AND LIMITATIONS OF THIS STUDY

- This adds a new angle to previous research of deficiencies reported in post-suicide audits where frequencies, but no interrelationships among variables have been known.
- While previous network studies in suicidology have focused on symptoms associated with suicidal ideation, this paper covers potential organizational targets for improving suicide prevention.
- The data source (The national open database for root cause analysis) was based on standardized reports performed by trained healthcare teams.
- The main limitation is that a relatively small proportion of all suicides were submitted to the database.

BACKGROUND

Suicide is one of the leading causes of death worldwide, affecting people of all ages, socio-economic 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 behavior, 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]

Post-suicide 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 standardized 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, (2021).[15]

Network analysis is an approach to statistically analyse and visualize core elements of a data set that has found applications in various fields spanning from mathematics and physics, to social sciences and psychology. The method is useful for modelling complex patterns of mutual, reinforcing relationships among positively 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 providing treatment to underlying illness, it stresses the of reduction of accessibility to lethal means,[40-45] combining immediate and long-term multi-level 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 organizational risk factors, better communication among professionals, proper education and provision of adequate guidelines have been suggested.[15, 49, 52]

Previous studies based exclusively on post-suicide RCA material, including systematic reviews, meta-analyses, and observational studies report inadequacies in cooperation,[62, 67-70] accessibility to care,[45, 68] assessments of suicidal risk,[67-71] and follow-up[72] as the main deficiencies in suicide prevention.

Network analysis has been used to examine and model suicidal behaviour, motives and psychopathology associated with suicidal ideation. According to the results, suboptimal treatment of underlying depression, affect regulation [73-79], or of psychotic symptoms [80] are associated with increased levels of suicidal ideation. Feelings of thwarted belongingness,[74, 75] and internal motives such as entrapment, hopelessness, and perceived burdensomeness[75, 77, 79, 81, 82] are also core factors 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, 82, 83] Personalizing treatment strategies, for instance by using electronic devices for repeated ecological momentary assessment, have been suggested as an application of these findings.[73, 75]

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 service related deficiencies preceding suicide, identify potential targets for clinical intervention and generate hypotheses for future research.

METHODS

This study followed the guidelines of the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) checklist for reporting cross sectional studies (Supplement 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 anonymized, so we could not link any information to actual patient records. The RCA reports were produced by RCA teams from 12 of Sweden's 21 regions, and covered suicides which have occurred among patients who were in contact with the healthcare services at the time of death. The RCA teams typically consisted of 3-4 investigators who had received special training in the RCA methodology. The investigators 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 RCA 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 RCA reports reflect the variability of data accessibility among the RCA teams. In some of the reports, particular details about the medical condition or specific circumstances have been omitted. Although we do not know the exact background to this, it may have been done to protect the integrity of those deceased, as suicides are relatively rare and single cases in rural areas could accidentally be identifiable by descriptions becoming too precise. As we only had access to the final RCA reports, we have not been able to scrutinize 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 217 patients in the RCA reports. For two persons, gender was reported as "other." Men were slightly overrepresented. Mood disorders were recorded as the most common type of primary diagnosis for both sexes.

Approximately half were between the ages of 18 and 49, and half were in contact with psychiatric services at time of death. Mood disorders were recorded as the most common type of primary diagnosis for both sexes.

Table 1. Patient demographics as reported to NITHA

	Total N = 217	Men n = 125	Women n = 90
NUMBER OF DAYS SINCE LAST CONTACT WITH HEALTHCARE AND DATE OF SUICIDE			
Mean (Median) ± SD	22.7 (4) ±91 [0-1124]		

[Min - Max]			
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 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 data	39	26	13
SETTING			
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 data	43	22	21

Data extraction and processing

A data coding tool was developed to organize the data into inductively constructed thematic 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 all were experienced in performing and peer-reviewing RCA reports at their own clinic. The teams worked independently but had regular meetings to discuss and modify the data coding tool. The data coding tool was audited by external reviewers and modified several times to cover all areas of interest in the RCAs. Every modification prompted a second review of previously reviewed cases. The

1
2
3 final version of the data coding tool was used to derive data from all 217 cases. Data were double-
4 checked for discrepancies; none were found in the final version of the dataset.
5
6

7 All 217 RCA reports were reviewed and coded by the two teams. The extracted raw data underwent
8 a keyword-based sorting of text strings in Microsoft Excel 2016 before being manually distributed
9 into the final categories, resulting in 499 registered deficiencies and 462 contributing factors.
10

11 Examples of typical cases are reported for each category in Table 2. While some minor
12 misclassifications in the original data were noted by the research teams, terminology used in the
13 original NITHA reports (including definition of missing data) was retained.
14
15
16

17 In the original RCA reports each item could be reported multiple times. The range for some items
18 varied from 1 to 6, depending on whether the RCA team had registered deficiencies in a merged or
19 split form. To avoid skewed results, all observations were binarized (using the simple algorithm “IF
20 count value ≥ 0 , THEN 1, ELSE 0”) before being entered into the network model.
21
22
23
24

25 **Data analysis**

26 The synthesized network model (the network, or the graph) contains two elements: nodes
27 (sometimes called vertices), representing variables, and edges (also called links) which represent
28 pairwise association among nodes.[16, 82] The network can be either directed, displaying the
29 influential effect from one node to another node, or undirected, where mutual influences are
30 indicated by a line between two nodes without any direction.[16] Centrality indices, such as strength,
31 betweenness and expected influence, are employed to evaluate the network.[16, 85] An overview of
32 different types of networks and applicable models has been published by Hevey, 2018.[23] For a
33 further discussion on psychometrics and network estimation, we refer to previous researchers in this
34 field.[31, 86-89]
35
36
37
38
39
40
41
42

43 Three networks were produced: one comprehensive network giving an overview of the major themes
44 (Figure 1-2), one network showing subthemes of deficiencies (Figure 3-4) and one network showing
45 subthemes of contributing factors (Supplement B). Frequencies and percentages are reported for
46 each variable (Table 2), alongside the centrality indices and stability measures (Figure 1-2). Data were
47 analysed using IBM Statistical Package for the Social Sciences version 25 and R version 3.5.0 (bootnet
48 package version 1.4.3, ggplot2 version 3.3.5, igraph package version 1.2.6, qgraph package version
49 1.6.9, IsingFit package version 0.3.1).[90-96] To visualize the dependencies, we used an undirected
50 network (formally called a pairwise Markov random field).[28, 87, 97] Relevant relationships among
51 nodes were estimated using IsingFit package which uses an enhanced least absolute shrinkage and
52 selection operator (eLASSO), based on the Ising Model. The operator reduces spurious edges by
53
54
55
56
57
58
59
60

1
2
3 suppressing non-zero connections to exactly zero. Selection is performed by combining logistic
4 regression (ℓ_1 -regularized) and a model selection based on the Extended Bayesian Information
5 Criterion (EBIC).[95] Since the network structures were sparse, the EBIC hyperparameter (γ) was
6 adjusted to 0 after careful consideration and comparisons of different settings. A γ set to 0 (can vary
7 from 0 to 1, default is 0.25) results in a lower shrinkage of estimated connections. As simulation
8 studies have shown, the likelihood of false positives is low and the specificity will still be higher
9 compared to a non-regularized partial correlation network.[23, 88, 98] The estimated networks were
10 then bootstrapped for accuracy and stability using the bootnet function, which performs a non-
11 parametric bootstrap to calculate the 95% bootstrapped confidence intervals (CIs) for the edges by
12 resampling the data with replacement 2500 times per network. The networks were visualised with
13 the plotting tools in qgraph, using the force directed layout “spring”, which employs the
14 Fruchterman-Reingold algorithm and draws nodes with higher centrality towards the center.[92, 99]
15 Lastly, network communities were calculated using the walktrap algorithm and plotted with igraph,
16 qgraph and ggplot2 plotting tools.[91, 93, 96] The data and R code necessary to reproduce our
17 results can be found on The Open Science Framework repository.[100-103]
18
19
20
21
22
23
24
25
26
27
28

29 Patient and public involvement

30 Neither patients nor the public were involved in this study.
31
32

33 RESULTS

34 Frequencies and percentages of reported variables

35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

Table 2: Frequencies and percentages of reported variables.

[Please insert table 2, which was too large to fit into the manuscript, here. It is included as supplemented material.]

In total, 499 deficiencies 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 27 percent of the cases involving follow-up, healthcare planning that could have provided a framework for treatment during the transition was also lacking. A large portion (76 percent) of the deficiencies categorised as problems in cooperation were linked to unclear delimitation of responsibility. Lack of adequate information was also a common explanatory

factor, accounting for 15 percent 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 (in RCA terminology also known as root causes) 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 organizational matters were also reported as common.

Network stability

Correlation stability coefficients (CS-coefficients) for each of the three networks (the major network, Deficiencies network, and Contributing factors network) are shown Table 3. The major network and the Deficiencies network are stable. As the CS-coefficients for the Contributing factors network was below the cut-off value 0.25, indicating instability, no final conclusions could be drawn. [87] The visualization of this network is included in Supplement B, along with the centrality indices calculated for this subset.

Table 1: 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

Central and peripheral nodes in the network

In this study, we have included the centrality indices node strength and edge strength to quantify impact on each network structure. Node strength is defined as the total sum of the magnitude of each of its edges. Nodes with fewer but stronger connections will be considered more central and thus yield a higher value, than nodes with many weak links.[23, 104, 105] The edge strength in a partial correlation or regularized network reflects the magnitude of the pairwise relationship between two nodes, while controlling for indirect influences via other nodes.[23, 88] The centrality

1
2
3 indices closeness, betweenness and expected influence (EI) were examined, but excluded from the
4 main section of this paper as the CS-coefficients for closeness and betweenness were below cut-off
5 and EI did not add anything to the interpretation that was not already explained by node strength.
6
7 Closeness is the average of the shortest path length from one node to every other node in the
8 network.[105] Betweenness describes how often one node function as an intermediate station on
9 the shortest path among neighbouring nodes. EI, like node strength, measures the importance of a
10 node in the network while also taking negative edges into account.[104] Calculated values for these
11 indices are included in Supplement C-E.

12
13
14
15
16
17 [Please insert Figure 1 here.]

18
19 The major network and significant differences of edges are shown in Figure 1.

20
21
22 [Please insert Figure 2 here.]

23
24 As shown in both Figure 1 and Figure 2, the nodes representing documentation, communication,
25 organization, follow-up, procedures and psychiatric evaluation were more central, compared to the
26 nodes related to safety, competence, contact with relatives, technical issues and cooperation.
27 Although the nodes involved all scored high in strength, two negative connections were found: 1)
28 between organization and communication, and 2) between psychiatric evaluation and procedures,
29 which may reflect how data were registered by the RCA teams.

30
31
32
33
34
35 [Please insert Figure 3 here.]

36
37 In the Deficiencies network (Figure 3), missed appointments, particularly the absence of booked
38 follow-ups but also cancellations made by the patient, scored high in node strength. Consequently,
39 missed assessments of suicide risk and continuous re-evaluation of the psychiatric status, were also
40 central, along with the node representing shortages in staff.

41
42
43
44
45 [Please insert Figure 4 here.]

46
47 In relation to these nodes, the nodes representing administrative problems, such as missed referrals
48 or other types of transferred information, safety issues, suboptimal contact with relatives, healthcare
49 plan being either absent or incomplete, and assessment not being recorded were more peripheral
50 (Figure 4.)

51
52
53
54 The third network, representing contributing factors, was too instable to estimate. Although the
55 nodes for work structure, resources, competence, and continuity had the highest node strength
56 centrality, the differences were not significant. Our recommendations are to examine these more
57
58
59
60

1
2
3 thoroughly in a future study with a larger sample. The topology and centrality indices for the
4 Contributing factors network are shown in Supplement B.
5
6

7 8 **Detected communities**

9 Communities were detected using the walktrap algorithm.[91] The nodes belonging to a community
10 are color marked in the visualizations of the networks in Figure 1 and Figure 2.
11
12

13 Two communities were present in the major network (Figure 1):
14

15 1) the nodes for the deficiencies psychiatric evaluation, follow-up, and the contributing factor for
16 procedures, routines, and policies.
17
18

19 2) the nodes for the deficiency communication and the nodes representing the contributing factors
20 organization and communication.
21
22

23 Analysis of the Deficiencies network (Fig. 2) resulted in two detected communities. The first included
24 the nodes representing understaffing, declined/missed appointments, and cases where future
25 appointments had not been booked. The second covered the nodes representing assessments of
26 suicide risk and of the overall mental condition.
27
28
29

30 31 **DISCUSSION**

32 The results of this study suggest that reported adversities are linked to a group of activities, rather
33 than to single mistakes. Providing suicidal patients with regular assessments, for instance, and
34 proposing adequate actions depends not only on the personal conditions of the evaluating clinician
35 and the patient being assessed, but also on proper work structures, good intrateam communication,
36 adequate routines and well-known procedures, and sufficient documentation of planned and
37 performed activities.
38
39
40
41
42

43 There are three main findings of this study. First, missed and declined appointments are central
44 features when examining elements occurring prior to the suicide. Together they account for a fifth of
45 the total amount of deficiencies. The current study does not examine the positive effects of booked
46 appointments and feedback loop systems which enhances the ability for healthcare providers to
47 react when a patient does not turn up on scheduled meetings. Neither have we investigated cases
48 with negative correlations between treatment cancellations and suicide. However, one hypothesis
49 drawn from our results and extrapolated conclusions from previous studies,[51, 52, 57, 58, 60-63, 65-
50 72] is that any disruption in treatment is negative, and cancellations made by the patient could be an
51 early warning sign of an ongoing exacerbation of the suicidal process. During phases of elevated
52 suicide risk, or in the early stages of recovery from a suicide attempt, the wellbeing of the patient is
53
54
55
56
57
58
59
60

1
2
3 frail, and the suicide risk may fluctuate rapidly.[58, 61, 64-66] Establishing a backup system, which
4 safeguards follow-up plans and alerts healthcare staff when patients cancel planned appointments,
5 could help improve patient safety. Second, many nodes are still disconnected. Even if it is likely that
6 there is an underlying covariance, the correlation is not independently significant. The sparsity of the
7 networks could be explained by the estimation procedure. Each network has been regularized in
8 order to reduce false positive connections and produce parsimonious graphs. When comparing them
9 with networks based on partial correlation matrices, many edges have been omitted due to the
10 penalization. It is therefore likely that other patterns would appear if more data were entered. Third,
11 the nodes representing security, technical issues and contact with relatives have both low
12 frequencies and low centrality. This means that adversities related to these areas are rarely reported.
13 One reason for this can be the very nature of the type of failures that can occur in these areas.
14 Denied access to an important medical record system at a specific time rarely affects more than one
15 or a few team members at a time. Ligature points, once removed, do not reappear at the exact same
16 location. Establishing and maintaining stable work conditions, on the other hand, is more elusive. The
17 concept of organizational prerequisites to provide safe interventions to suicidal patients is subjective
18 which could lead to a higher rate of recurrences of management related issues. While adverse events
19 concerning security at the inpatient facilities were rare, the transition to outpatient services seem to
20 be associated with elevated risk levels. This is not very surprising, as transitions imply a change in
21 primary caregiver and a shift from short-term to long-term treatment goals. Our results only support
22 conclusions about an observed general relationship. To gain more knowledge about the mechanisms
23 involved, there is a need for more network studies focusing more extensively on these steps of the
24 process. Even though interviews with relatives were included in 64 % of the reports, their perspective
25 were only reflected in 1 % of the deficiencies (Table 2). This situation has been previously described
26 by Bouwman et al. (2018). After examining policies from 15 healthcare organizations and spoken to
27 35 stakeholders (including patient, families and their counsellors, national regulators and
28 professionals) they concluded that involvement by relatives, insofar they had been involved, rarely
29 extended beyond aftercare and information provision.[50] With this in mind, there is reason to
30 believe that our results would benefit from being complemented with studies based on narratives
31 from a contrasting point of view.
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50

51 We acknowledge that from a general point of view, some of our findings are similar to the
52 conclusions drawn by our colleagues in the same field. Suicide risk is multifactorial, and decisions
53 about appropriate safety measures are dependent on factors on both individual and structural
54 levels.[5, 6, 10, 38, 40, 42, 44, 46, 48, 49, 51, 53-55, 57, 58, 60-64, 66-69] However, following the
55 argumentation of Fried and Robinaugh (2021) on complexity, adverse events cannot be prevented by
56
57
58
59
60

1
2
3 understanding the single components alone, neglecting the interactions among them.[106] If the
4 value of a unique node is determined not only by the intrinsic properties of the node itself, but by its
5 relations to other objects, the study of single factors will not yield any ultimate answers about how
6 to prevent undesired events. To gain more knowledge, we must first examine the dynamics of the
7 systems from which adversity arises.
8
9

11 12 **CONCLUSION**

13
14 Applying network analysis to investigate patient safety adds to previous research by elucidating
15 patterns of associated factors which may be unclear when only incident rate is considered. The
16 results shows that failed assessments and cancelled treatments during follow-up are both frequent
17 and have a high centrality in relation to the other nodes in the network and could function as a
18 warning sign for exacerbation. Organizational instability, in terms of understaffing, shortages of
19 resources and suboptimal work procedures are also prominent features of the networks. Although
20 comparative studies are needed before any final conclusions can be drawn, focusing on these areas
21 may improve patient safety in suicide prevention.
22
23
24
25
26
27

28 29 **STRENGTHS AND LIMITATIONS**

30
31 Strengths of the study include data collected from NITHA, the only open national resource in Sweden
32 for the dissemination of RCA reports. These reports were produced in a standardized manner by
33 trained RCA teams, and the data were examined and categorized by four professionals, all
34 experienced in performing and peer-reviewing RCA reports. Considering the dynamic nature of
35 deficiencies in healthcare where underlying factors are rarely sharply outlined, but rather multi-
36 layered, network analysis can bring new and valuable insights of risk-prone areas.
37
38
39

40
41 The study also has several limitations. Since we obtained our data exclusively through the NITHA
42 system, other post-suicide investigations were not included. Because regional institutional praxis
43 concerning submission to the NITHA database varied, RCA reports cannot be considered
44 representative for the country of Sweden. A relatively small proportion of all suicides were submitted
45 to the database, and therefore selection bias cannot be ruled out. The RCA methodology is designed
46 to scrutinize organizations and detect possible causes for systematic negative output. Consequently,
47 the reported findings may focus on incidental discoveries, rather than some latent factor which lies
48 beyond the scope of the protocol. Moreover, since RCA aims to identify organizational
49 vulnerabilities, the reports lack certain details concerning the patients themselves. As we did not
50 have access to original records, we have not been able to verify the accuracy of the content in the
51 RCA reports. Therefore, our findings will reflect any misclassification done by the RCA teams during
52 the initial investigation process. Lastly, the classification tool used by the auditing teams has not
53
54
55
56
57
58
59
60

1
2
3 been validated by independent reviewers. The data were qualitatively categorized and could have
4 been organized differently.
5
6

7 **FUTURE RESEARCH**

9 Based on the findings of this study, further research on the protective effects of implemented
10 security systems which help healthcare providers to react when patients drop out of treatment is
11 suggested. Considering the relatively low number of observations, we also recommend future
12 network studies based on a larger sample. To gain more insights into the perspectives of patients and
13 relatives, network studies based on their experiences would be a fruitful approach.
14
15
16
17

18 **ACKNOWLEDGEMENTS**

19 The authors would like to express their gratitude to Cecilia Boldt-Christmas, Marzia Dellepiane, and
20 Evalena von Hausswolff who participated in the data extraction and coding.
21
22
23

24 **CONTRIBUTORS**

25 MR designed the study, collected and registered the data, performed the analyses, and drafted the
26 manuscript. EC, LA, MW, and TB contributed to the study design, analyses, and manuscript revision.
27
28 All authors read and approved the final manuscript.
29
30
31

32 **COMPETING INTERESTS**

33
34 There are no competing interests for any author.
35
36

37 **FUNDING**

38 This work was supported by the Affective Clinic, Sahlgrenska University Hospital, Gothenburg, Region
39 Västra Götaland (no specific grant number).
40
41
42

43 **DATA AVAILABILITY STATEMENT**

44 Copies of used R scripts and data sets can be found in our repository at Open Science Framework.
45
46
47

48 **ETHICAL REVIEW**

49 According to the Swedish Act Concerning the Ethical Review of Research Involving Humans
50 (2003:460), this study did not require ethical review as it did not involve human participants.
51
52
53
54
55
56
57
58
59
60

REFERENCES

1. World Health Organization. Suicide worldwide in 2019: global health estimates. Geneva: World Health Organization; 2021. Available from: <https://www.who.int/publications/i/item/9789240026643> (accessed October 19, 2021).
2. World Health Organization. Preventing suicide: a global imperative. 2014. Available from: http://apps.who.int/iris/bitstream/handle/10665/131056/9789241564779_eng.pdf?sequence=1 (accessed January 19, 2019).
3. Ropper AH, Fazel S, Runeson B. Suicide. *The New England Journal of Medicine*. 2020;382(3):266-74.
4. Too LS, Spittal MJ, Bugeja L, et al. The association between mental disorders and suicide: A systematic review and meta-analysis of record linkage studies. *J Affect Disord*. 2019;259:302-13.
5. Runeson B, Haglund A, Lichtenstein P, et al. Suicide risk after nonfatal self-harm: a national cohort study, 2000-2008. *J Clin Psychiatry*. 2016;77(2):240-6.
6. Large M, Sharma S, Cannon E, et al. Risk Factors for Suicide Within a Year of Discharge from Psychiatric Hospital: A Systematic Meta-Analysis. *Aust N Z J Psychiatry*. 2011;45(8):619-28.
7. Waern M, Kaiser N, Renberg ES. Psychiatrists' experiences of suicide assessment. *BMC Psychiatry*, 2016, Vol 16. 2016;16.
8. Steeg S, Quinlivan L, Nowland R, et al. Accuracy of risk scales for predicting repeat self-harm and suicide: a multicentre, population-level cohort study using routine clinical data.(Report). *BMC Psychiatry*. 2018;18(1).
9. Smith MJ, Bouch J, Bradstreet S, et al. Health services, suicide, and self-harm: patient distress and system anxiety. *Lancet Psychiatry*. 2015;2(3):275-80.

10. Hoffmire C, Stephens B, Morley S, et al. VA Suicide Prevention Applications Network: A National Health Care System–Based Suicide Event Tracking System. *Public Health Rep.* 2016;131(6):816-21.
11. Clarke I. Learning from critical incidents. *Advances in Psychiatric Treatment.* 2018;14(6):460-8.
12. Ericsson C, Hessel Å. *Risikanalys och händelseanalys: analysmetoder för att öka patientsäkerheten : handbok* [Risk analysis and Root Cause Analysis: analysis methods to improve patient safety: handbook]. Stockholm: Sveriges kommuner och landsting; 2015. Available from: <http://webbutik.skl.se/sv/artiklar/risikanalys-och-handelseanalys-analysmetoder-for-att-oka-patientsakerheten.html> (accessed October 19, 2021).
13. Bowie P, Skinner J, de Wet C. Training health care professionals in root cause analysis: a cross-sectional study of post-training experiences, benefits and attitudes. *BMC Health Serv Res.* 2013;13:50-.
14. Aboumradi M, Neily J, Watts BV. Teaching Root Cause Analysis Using Simulation: Curriculum and Outcomes. *Journal of medical education and curricular development.* 2019;6:2382120519894270-.
15. Fröding E, Gäre BA, Westrin Å, et al. Suicide as an incident of severe patient harm: a retrospective cohort study of investigations after suicide in Swedish healthcare in a 13-year perspective. *BMJ Open.* 2021;11(3):e044068.
16. Newman M. *Networks.* Oxford: Oxford: Oxford University Press; 2018.
17. Luke DA, Harris JK. Network Analysis in Public Health: History, Methods, and Applications. *Annu Rev Public Health.* 2007;28(1):69-93.
18. Borsboom D. Psychometric perspectives on diagnostic systems. *J Clin Psychol.* 2008;64(9):1089-108.
19. Borsboom D, Cramer AO. Network analysis: an integrative approach to the structure of psychopathology. *Annu Rev Clin Psychol.* 2013;9:91-121.

- 1
2
3
4 20. Schmittmann VD, Cramer AOJ, Waldorp LJ, et al. Deconstructing the
5
6 construct: A network perspective on psychological phenomena. *New*
7
8 *Ideas Psychol.* 2013;31(1):43-53.
- 9
10 21. van der Maas HL, Dolan CV, Grasman RP, et al. A dynamical model of
11
12 general intelligence: the positive manifold of intelligence by mutualism.
13
14 *Psychol Rev.* 2006;113(4):842-61.
- 15
16 22. Cramer AOJ, Waldorp LJ, van der Maas HLJ, et al. Comorbidity: A
17
18 network perspective. *The Behavioral and brain sciences.* 2010;33(2-
19
20 3):15-150.
- 21
22 23. Hevey D. Network analysis: a brief overview and tutorial. *Health*
23
24 *Psychology and Behavioral Medicine.* 2018;6(1):301-28.
- 25
26 24. Beard C, Millner A, Forgeard M, et al. Network analysis of depression
27
28 and anxiety symptom relationships in a psychiatric sample. *Psychol*
29
30 *Med.* 2016;46(16):3359-69.
- 31
32 25. Fried EI, van Borkulo CD, Cramer AOJ, et al. Mental disorders as
33
34 networks of problems: a review of recent insights. *Soc Psychiatry*
35
36 *Psychiatr Epidemiol.* 2017;52(1):1-10.
- 37
38 26. Fried EI, Bockting C, Arjadi R, et al. From Loss to Loneliness: The
39
40 Relationship Between Bereavement and Depressive Symptoms. *Journal*
41
42 *of abnormal psychology (1965).* 2015;124(2):256-65.
- 43
44 27. Borsboom D, Cramer AOJ, Schmittmann VD, et al. The small world of
45
46 psychopathology. *PLoS One.* 2011;6(11):e27407-e.
- 47
48 28. Borsboom D, Deserno MK, Rhemtulla M, et al. Network analysis of
49
50 multivariate data in psychological science. *Nature Reviews Methods*
51
52 *Primers.* 2021;1(1):58.
- 53
54 29. Bringmann LF, Lemmens LHJM, Huibers MJH, et al. Revealing the
55
56 dynamic network structure of the Beck Depression Inventory-II. *Psychol*
57
58 *Med.* 2015;45(4):747-57.
- 59
60

- 1
2
3
4 30. Costantini G, Epskamp S, Borsboom D, et al. State of the aRt
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
31. Costantini G, Richetin J, Preti E, et al. Stability and variability of
personality networks. A tutorial on recent developments in network
psychometrics. *Pers Individ Dif*. 2019;136:68-78.
32. Cramer AOJ, van der Sluis S, Noordhof A, et al. Dimensions of Normal
Personality as Networks in Search of Equilibrium: You Can't Like Parties
if You Don't Like People. *European Journal of Personality*.
2012;26(4):414-31.
33. Forkmann T, Teismann T, Stenzel J-S, et al. Defeat and entrapment:
more than meets the eye? Applying network analysis to estimate
dimensions of highly correlated constructs.(Report). *BMC Med Res
Methodol*. 2018;18(1).
34. Richetin J, Preti E, Costantini G, et al. The centrality of affective
instability and identity in Borderline Personality Disorder: Evidence from
network analysis. *PLoS One*. 2017;12(10).
35. Isvoranu A-M, Abidin E, Chong SA, et al. Extended network analysis:
from psychopathology to chronic illness. *BMC Psychiatry*.
2021;21(1):119-.
36. Isvoranu A-M, van Borkulo CD, Boyette L-L, et al. A Network Approach
to Psychosis: Pathways Between Childhood Trauma and Psychotic
Symptoms. *Schizophr Bull*. 2017;43(1):187-96.
37. Köhne ACJ, Isvoranu A-M. A Network Perspective on the Comorbidity of
Personality Disorders and Mental Disorders: An Illustration of
Depression and Borderline Personality Disorder. *Front Psychol*.
2021;12:680805-.
38. Cheng A, Chen T, Chen CC, et al. Psychosocial and psychiatric risk
factors for suicide: case-control psychological autopsy study. *Br J
Psychiatry*. 2000(177):360-5.

- 1
2
3
4 39. Berman AL, Silverman MM. Suicide Risk Assessment and Risk
5 Formulation Part II : Suicide Risk Formulation and the Determination of
6 Levels of Risk. *Suicide and Life-Threatening Behavior*. 2014;44(4):432-
7 43.
8
9
- 10
11 40. Pirkis J, Too LS, Spittal MJ, et al. Interventions to reduce suicides at
12 suicide hotspots: a systematic review and meta-analysis. *Lancet*
13 *Psychiatry*. 2015;2(11):994-1001.
14
15
- 16 41. Barker E, Kolves K, De Leo D. Rail-suicide prevention: Systematic
17 literature review of evidence-based activities. *Asia-Pacific Psychiatry*.
18 2017;9(3):e12246.
19
20
- 21 42. Zalsman G, Hawton K, Wasserman D, et al. Suicide prevention
22 strategies revisited: 10-year systematic review. *Lancet Psychiatry*.
23 2016;3(7):646-59.
24
25
- 26 43. Zalsman G, Hawton K, Wasserman D, et al. Evidence-based national
27 suicide prevention taskforce in Europe: A consensus position paper. *Eur*
28 *Neuropsychopharmacol*. 2017;27(4):418-21.
29
30
- 31 44. Mann JJ, Apter A, Bertolote J, et al. Suicide prevention strategies: a
32 systematic review. *JAMA*. 2005;294(16):2064-74.
33
34
- 35 45. Vine R, Mulder C. After an inpatient suicide: the aim and outcome of
36 review mechanisms. *Australasian Psychiatry*. 2013;21(4):359-64.
37
38
- 39 46. Meerwijk EL, Parekh A, Oquendo MA, et al. Direct versus indirect
40 psychosocial and behavioural interventions to prevent suicide and
41 suicide attempts: a systematic review and meta-analysis. *Lancet*
42 *Psychiatry*. 2016;3(6):544-54.
43
44
- 45 47. Sakashita T, Oyama H. Overview of community-based studies of
46 depression screening interventions among the elderly population in
47 Japan. *Aging Ment Health*. 2016;20(2):231-9.
48
49
- 50 48. Cole-King A, Parker V, Williams H, et al. Suicide prevention: are we
51 doing enough? *Advances in Psychiatric Treatment*. 2018;19(4):284-91.
52
53
54
55
56
57
58
59
60

- 1
2
3
4 49. Huisman A, Kerkhof AJFM, Robben PBM. Suicides in users of mental
5 health care services: treatment characteristics and hindsight reflections.
6 *Suicide Life Threat Behav.* 2011;41(1):41.
7
- 8
9 50. Bouwman R, De Graaff B, De Beurs D, et al. Involving Patients and
10 Families in the Analysis of Suicides, Suicide Attempts, and Other
11 Sentinel Events in Mental Healthcare: A Qualitative Study in The
12 Netherlands. *Int J Environ Res Public Health.* 2018;15(6):1104.
13
- 14
15 51. Burgess P, Pirkis J, Morton J, et al. Lessons From a Comprehensive
16 Clinical Audit of Users of Psychiatric Services Who Committed Suicide.
17 *Psychiatr Serv.* 2000;51(12):1555-60.
18
- 19
20 52. Roos af Hjelmsäter E, Ros A, Gäre BA, et al. Deficiencies in healthcare
21 prior to suicide and actions to deal with them: a retrospective study of
22 investigations after suicide in Swedish healthcare. *BMJ Open.*
23 2019;9(12):e032290.
24
- 25
26 53. Large M, Smith G, Sharma S, et al. Systematic review and meta-
27 analysis of the clinical factors associated with the suicide of psychiatric
28 in-patients. *Acta Psychiatr Scand.* 2011;124(1):18-9.
29
- 30
31 54. Meehan J, Kapur N, Hunt I, et al. Suicide in Mental Health In-Patients
32 and within 3 Months of Discharge. *The British Journal of Psychiatry.*
33 2006;188(2):129-34.
34
- 35
36 55. Changchien T-C, Yen Y-C, Wang Y-J, et al. Establishment of a
37 Comprehensive Inpatient Suicide Prevention Network by Using Health
38 Care Failure Mode and Effect Analysis. *Psychiatr Serv.* 2019;70(6):518-
39 21.
40
- 41
42 56. Williams SC, Schmaltz SP, Castro GM, et al. Incidence and Method of
43 Suicide in Hospitals in the United States. *The Joint Commission Journal*
44 *on Quality and Patient Safety.* 2018;44(11):643-50.
45
- 46
47 57. Iliachenko EK, Ragazan DC, Eberhard J, et al. Suicide mortality after
48 discharge from inpatient care for bipolar disorder: A 14-year Swedish
49 national registry study. *J Psychiatr Res.* 2020;127:20-7.
50
51
52
53
54
55
56
57
58
59
60

- 1
2
3
4 58. Haglund A, Lysell H, Larsson H, et al. Suicide Immediately After
5 Discharge From Psychiatric Inpatient Care: A Cohort Study of Nearly 2.9
6 Million Discharges. *The Journal of clinical psychiatry*. 2019;80(2).
7
8
- 9 59. Appleby L, Dennehy JA, Thomas CS, et al. Aftercare and clinical
10 characteristics of people with mental illness who commit suicide: a case-
11 control study. *The Lancet*. 1999;353(9162):1397-400.
12
13
- 14 60. Qin P, Nordentoft M. Suicide Risk in Relation to Psychiatric
15 Hospitalization: Evidence Based on Longitudinal Registers. *JAMA*
16 *Psychiatry*. 2005;62(4):427-32.
17
18
- 19 61. Chung D, Hadzi-Pavlovic D, Wang M, et al. Meta-analysis of suicide
20 rates in the first week and the first month after psychiatric
21 hospitalisation. *BMJ Open*. 2019;9(3).
22
23
- 24 62. Riblet VN, Shiner RB, Watts RB, et al. Death by Suicide Within 1 Week
25 of Hospital Discharge: A Retrospective Study of Root Cause Analysis
26 Reports. *The Journal of Nervous and Mental Disease*. 2017;205(6):436-
27 42.
28
29
- 30 63. Valenstein M, Kim HM, Ganoczy D, et al. Higher-risk periods for suicide
31 among VA patients receiving depression treatment: Prioritizing suicide
32 prevention efforts. *J Affect Disord*. 2009;112(1):50-8.
33
34
- 35 64. Bickley H, Hunt IM, Windfuhr K, et al. Suicide Within Two Weeks of
36 Discharge From Psychiatric Inpatient Care: A Case-Control Study.
37 *Psychiatr Serv*. 2013;64(7):653-9.
38
39
- 40 65. Appleby L, Dennehy JA, Thomas CS, et al. Aftercare and clinical
41 characteristics of people with mental illness who commit suicide: a case-
42 control study. *The Lancet (British edition)*. 1999;353(9162):1397-400.
43
44
- 45 66. Chung DT, Ryan CJ, Hadzi-Pavlovic D, et al. Suicide Rates After
46 Discharge From Psychiatric Facilities: A Systematic Review and Meta-
47 analysis
48 Suicide Rates After Discharge From Psychiatric Facilities
49 Suicide Rates After Discharge From Psychiatric Facilities. *JAMA Psychiatry*.
50 2017;74(7):694-702.
51
52
53
54
55
56
57
58
59
60

- 1
2
3
4 67. Mills PD, Gallimore BI, Watts BV, et al. Suicide attempts and
5 completions in Veterans Affairs nursing home care units and long-term
6 care facilities: a review of root-cause analysis reports. *Int J Geriatr*
7 *Psychiatry*. 2016;31(5):518-25.
8
9
10
11 68. Mills PD, Huber SJ, Vince Watts B, et al. Systemic vulnerabilities to
12 suicide among veterans from the Iraq and Afghanistan Conflicts: review
13 of case reports from a National Veterans Affairs Database. *Suicide Life*
14 *Threat Behav*. 2011;41(1):21-32.
15
16
17 69. Mills PD, Neily J, Luan D, et al. Actions and implementation strategies to
18 reduce suicidal events in the Veterans Health Administration. *Jt Comm J*
19 *Qual Patient Saf*. 2006;32(3):130-41.
20
21
22
23 70. Aboumrad M, Shiner B, Riblet N, et al. Factors contributing to cancer-
24 related suicide: A study of root-cause analysis reports. *Psychooncology*.
25 2018;27(9):2237-44.
26
27
28
29 71. Mills PD, Watts BV, Shiner B, et al. Adverse events occurring on mental
30 health units. *Gen Hosp Psychiatry*. 2018;50:63-8.
31
32
33 72. Gillies D, Chicop D, O'Halloran P. Root Cause Analyses of Suicides of
34 Mental Health Clients. *Crisis: The Journal of Crisis Intervention and*
35 *Suicide Prevention*. 2015;36(5):316-24.
36
37
38
39 73. de Beurs D. Network Analysis: A Novel Approach to Understand
40 Suicidal Behaviour. *Int J Environ Res Public Health*. 2017;14(3):219.
41
42
43 74. Gijzen MWM, Rasing SPA, Creemers DHM, et al. Suicide ideation as a
44 symptom of adolescent depression. a network analysis. *J Affect Disord*.
45 2021;278:68-77.
46
47
48 75. Rath D, de Beurs D, Hallensleben N, et al. Modelling suicide ideation
49 from beep to beep: Application of network analysis to ecological
50 momentary assessment data. *Internet Interventions*. 2019;18:100292.
51
52
53 76. Shiratori Y, Tachikawa H, Nemoto K, et al. Network analysis for motives
54 in suicide cases: A cross-sectional study. *Psychiatry Clin Neurosci*.
55 2014;68(4):299-307.
56
57
58
59
60

- 1
2
3
4 77. De Beurs D, Fried EI, Wetherall K, et al. Exploring the psychology of
5 suicidal ideation: A theory driven network analysis. *Behav Res Ther.*
6 2019;120:103419.
7
8
9 78. Núñez D, Ulloa JL, Guillaume S, et al. Suicidal ideation and affect lability
10 in single and multiple suicidal attempters with Major Depressive
11 Disorder: An exploratory network analysis. *J Affect Disord.*
12 2020;272:371-9.
13
14
15 79. Bloch-Elkouby S, Gorman B, Schuck A, et al. The Suicide Crisis
16 Syndrome: A Network Analysis. *J Couns Psychol.* 2020;67(5):595-607.
17
18
19 80. Núñez D, Fresno A, van Borkulo CD, et al. Examining relationships
20 between psychotic experiences and suicidal ideation in adolescents
21 using a network approach. *Schizophr Res.* 2018;201:54-61.
22
23
24 81. De Beurs D, Fried EI, Wetherall K, et al. Exploring the psychology of
25 suicidal ideation: A theory driven network analysis. *Behaviour research*
26 *and therapy.* 2019;120.
27
28
29 82. de Beurs D, Vancayseele N, van Borkulo C, et al. The association
30 between motives, perceived problems and current thoughts of self-harm
31 following an episode of self-harm. A network analysis. *J Affect Disord.*
32 2018;240:262-70.
33
34
35 83. Simons JS, Simons RM, Walters KJ, et al. Nexus of despair: A network
36 analysis of suicidal ideation among veterans. *Archives of suicide*
37 *research.* 2020;24(sup1):314-36.
38
39
40 84. Inera. *Nationellt IT-stöd för händelseanalyser - NITHA Kunskapsbank*
41 [National database for root cause analyses]. October 19, 2021.
42 Available from: <https://nitha.inera.se/Learn>.
43
44
45 85. Bringmann LF, Elmer T, Epskamp S, et al. What do centrality measures
46 measure in psychological networks? *J Abnorm Psychol.*
47 2019;128(8):892-903.
48
49
50
51
52
53
54
55
56
57
58
59
60

- 1
2
3 86. Williams DR, Rhemtulla M, Wysocki AC, et al. On Nonregularized
4 Estimation of Psychological Networks. *Multivariate Behavioral*
5 *Research*. 2019;54(5):719-50.
6
7
- 8
9 87. Epskamp S, Borsboom D, Fried EI. Estimating psychological networks
10 and their accuracy: A tutorial paper. *Behav Res Methods*.
11 2018;50(1):195-212.
12
13
- 14 88. Epskamp S, Fried EI. A Tutorial on Regularized Partial Correlation
15 Networks. *Psychol Methods*. 2018;23(4):617-34.
16
17
- 18 89. Epskamp S, Waldorp LJ, Möttus R, et al. The Gaussian Graphical Model
19 in Cross-Sectional and Time-Series Data. *Multivariate behavioral*
20 *research*. 2018;53(4):453-80.
21
22
- 23 90. van Borkulo C, Epskamp, S., & Robitzsch, A. IsingFit: Fitting Ising
24 Models Using the Lasso Method. 2016. Available from: [https://CRAN.R-](https://CRAN.R-project.org/package=IsingFit)
25 [project.org/package=IsingFit](https://CRAN.R-project.org/package=IsingFit).
26
27
- 28 91. Csardi GN, T. The igraph software package for complex network
29 research, InterJournal, Complex Systems 1695. 2006. Available from:
30 <https://igraph.org>.
31
32
- 33 92. Epskamp S, Constantini, G., Haslbeck, J. & Isvoranu, A. Package
34 qgraph: manual 2021. Available from: [https://cran.r-](https://cran.r-project.org/web/packages/qgraph/qgraph.pdf)
35 [project.org/web/packages/qgraph/qgraph.pdf](https://cran.r-project.org/web/packages/qgraph/qgraph.pdf).
36
37
- 38 93. Epskamp S, Cramer, A., Waldorp, L., Schmittmann, V. & Borsboom, D.,
39 . qgraph: Network Visualizations of Relationships in Psychometric Data:
40 Journal of Statistical Software, 48(4), 1-18. ; 2012. Available from:
41 <http://www.jstatsoft.org/v48/i04/>.
42
43
- 44 94. R Core Team. R: A language and environment for statistical computing
45 Vienna, Austria: R Foundation for Statistical Computing; 2021. Available
46 from: <https://www.R-project.org/>.
47
48
- 49 95. van Borkulo & Epskamp SwcfR, A. Package 'IsingFit' 2016. Available
50 from: <https://cran.r-project.org/web/packages/IsingFit/IsingFit.pdf>.
51
52
53
54
55
56
57
58
59
60

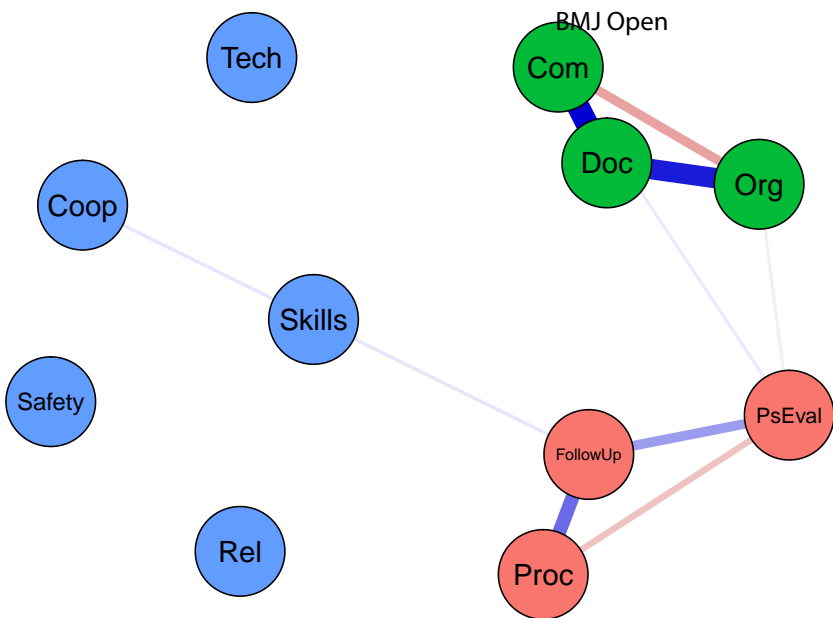
- 1
2
3
4 96. Wickham H. *ggplot2: Elegant Graphics for Data Analysis*. New York: Springer-Verlag New York; 2016.
- 5
6
7 97. Epskamp S, van Borkulo CD, van der Veen DC, et al. Personalized
8 Network Modeling in Psychopathology: The Importance of
9 Contemporaneous and Temporal Connections. *Clinical Psychological
10 Science*. 2018;6(3):416-27.
- 11
12
13 98. van Borkulo CD, Borsboom D, Epskamp S, et al. A new method for
14 constructing networks from binary data. *Sci Rep*. 2014;4(1):5918-.
- 15
16
17 99. Fruchterman TMJ, Reingold EM. Graph drawing by force-directed
18 placement. *Software: Practice and Experience*. 1991;21(11):1129-64.
- 19
20
21 [dataset] 100. Rex M. Data from: Final Major Network. The Open Science
22 Framework Repository, October 19, 2021. Available from:
23 https://osf.io/3dhtf/?view_only=084563d6b38a4f5aa32f6d76c50c0a34.
- 24
25
26 [dataset] 101. Rex M. Data from: Final deficiencies network. The Open
27 Science Framework Repository, October 20, 2021. Available from:
28 https://osf.io/3dhtf/?view_only=084563d6b38a4f5aa32f6d76c50c0a34.
- 29
30
31 [dataset] 102. Rex M. Data from: Final Contributing factors network. The Open
32 Science Framework Repository, October 14, 2021. Available from:
33 https://osf.io/3dhtf/?view_only=084563d6b38a4f5aa32f6d76c50c0a34.
- 34
35
36 103. Rex M. R script used in the manuscript Coexisting service related
37 factors preceding suicide: A network analysis. The Open Science
38 Framework Repository, October 21, 2021. Available from:
39 https://osf.io/3dhtf/?view_only=084563d6b38a4f5aa32f6d76c50c0a34.
- 40
41
42 104. Robinaugh DJ, Millner AJ, McNally RJ. Identifying highly influential
43 nodes in the complicated grief network. *J Abnorm Psychol*.
44 2016;125(6):747-57.
- 45
46
47 105. de Beurs DP, van Borkulo CD, O'Connor RC. Association between
48 suicidal symptoms and repeat suicidal behaviour within a sample of
49 hospital-treated suicide attempters. *BJPsych Open*. 2017;3(3):120-6.
- 50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

106. Fried EI, Robinaugh DJ. Systems all the way down: embracing complexity in mental health research. *BMC Med.* 2020;18(1):205-.

For peer review only

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38

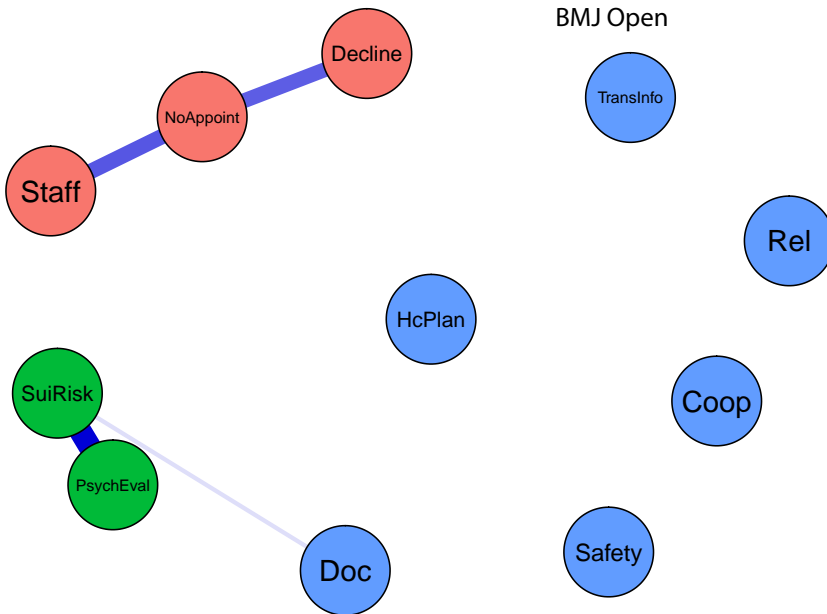


- Community 1
- Community 2
- Disconnected nodes

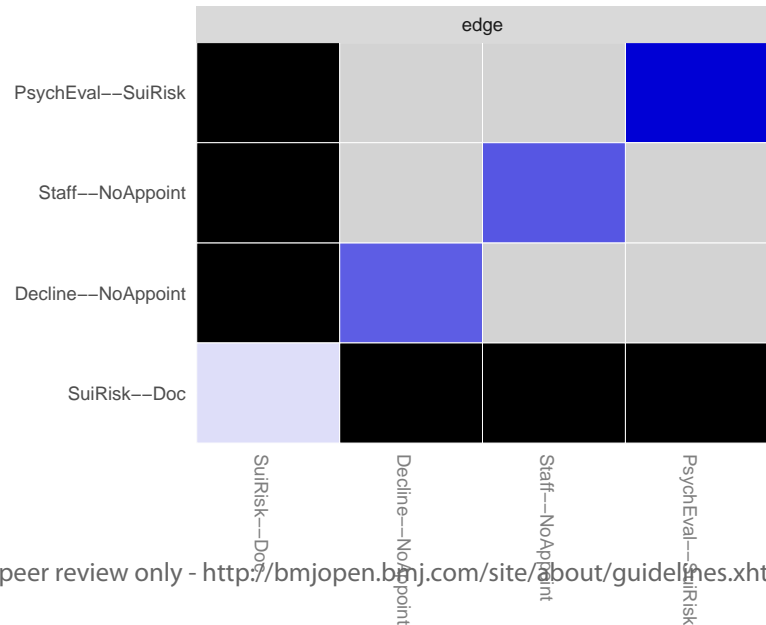
edge

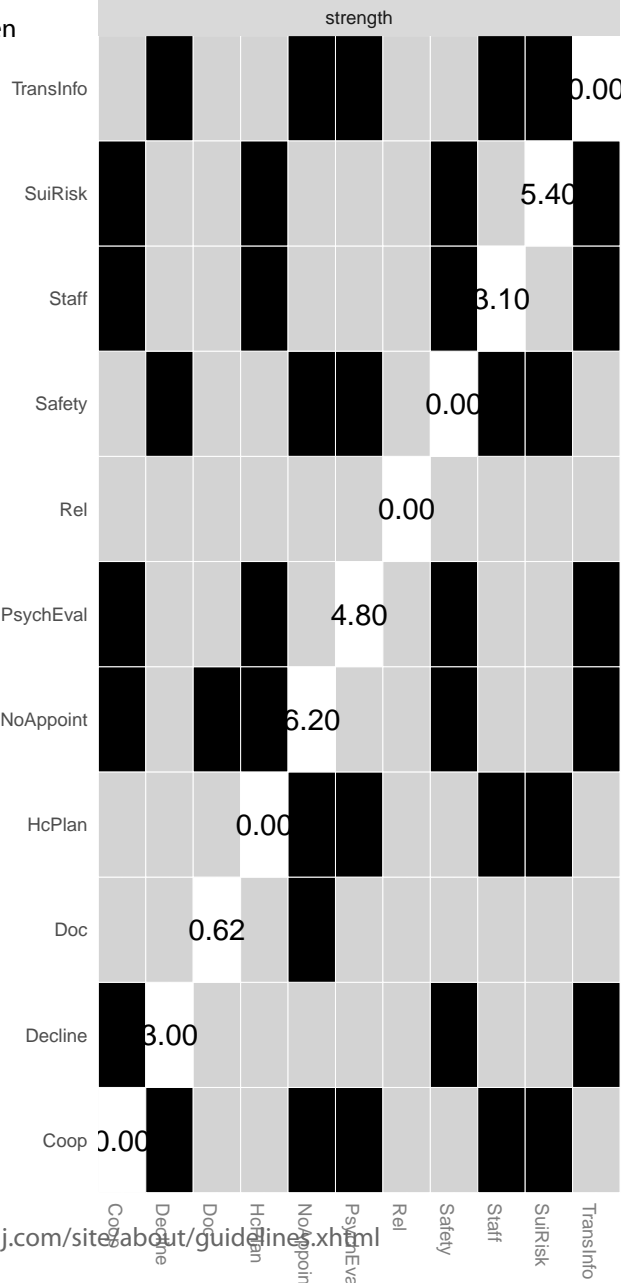
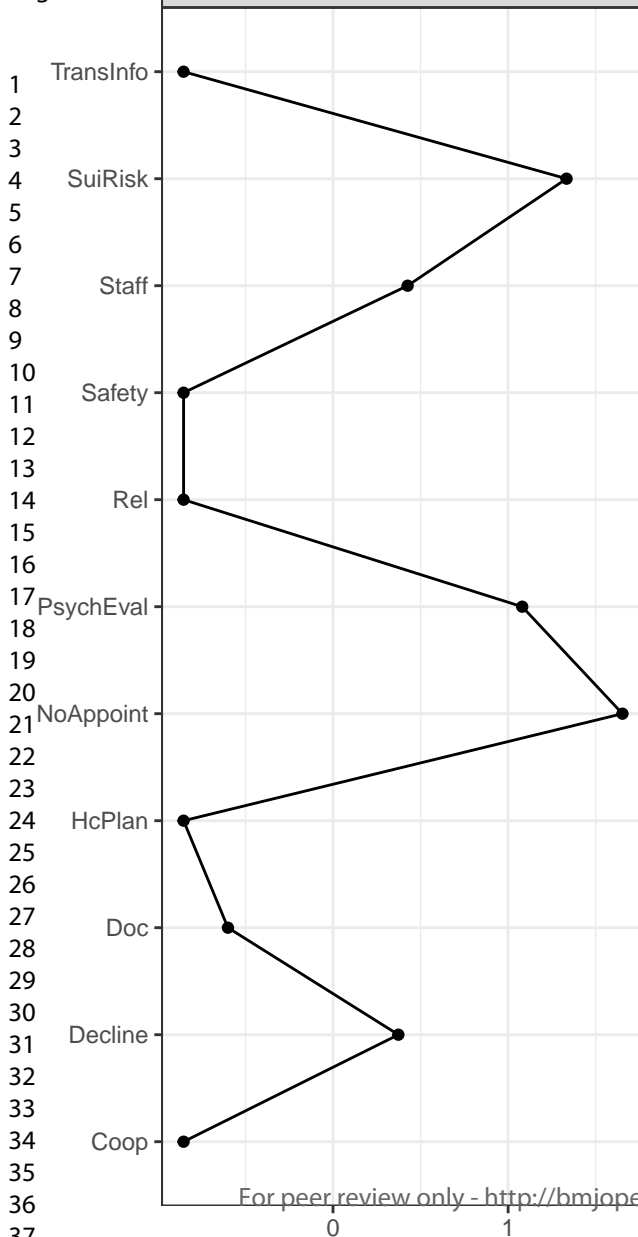
Doc—Com									
Doc—Org									
FollowUp—Proc									
PsEval—FollowUp									
Coop—FollowUp									
PsEval—Com									
PsEval—Org									
PsEval—Proc									
Org—Com									
	Org—Com	PsEval—Proc	PsEval—Org	PsEval—Com	Coop—FollowUp	PsEval—FollowUp	FollowUp—Proc	Doc—Org	Doc—Com

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38



- Community 1
- Community 2
- Disconnected nodes





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	4-5
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	4-5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
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	6-7
Bias	9	Describe any efforts to address potential sources of bias	6-8, 12-13
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	8-10

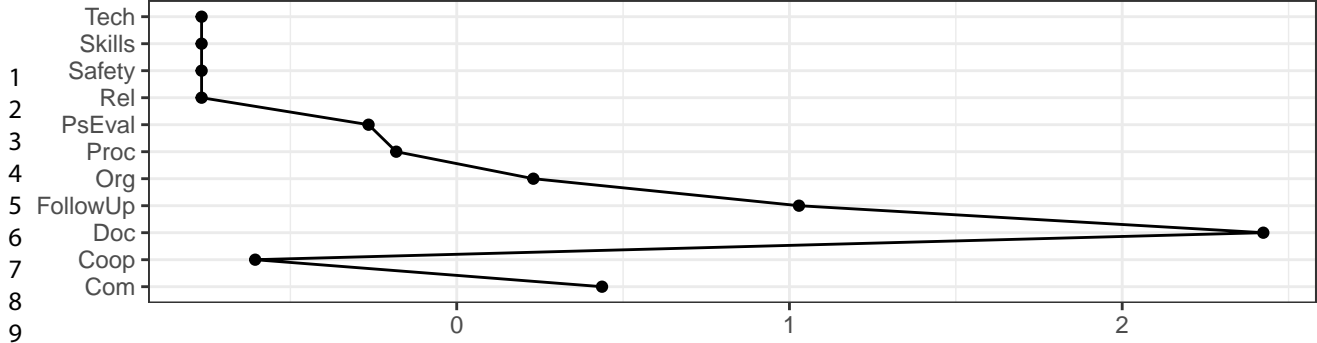
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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	9
		(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	11
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	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11-13
Generalisability	21	Discuss the generalisability (external validity) of the study results	11-13
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	14

*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.

BMJ Open Influence

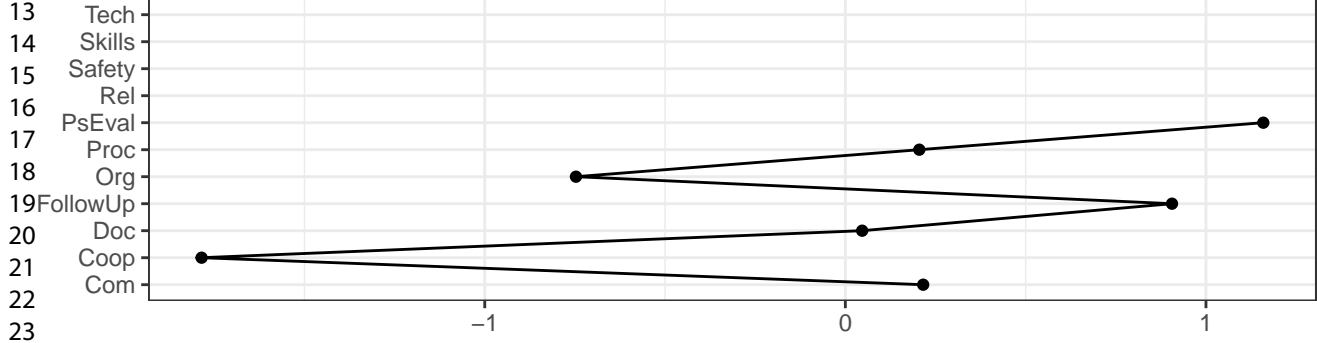


9

10

11

Closeness



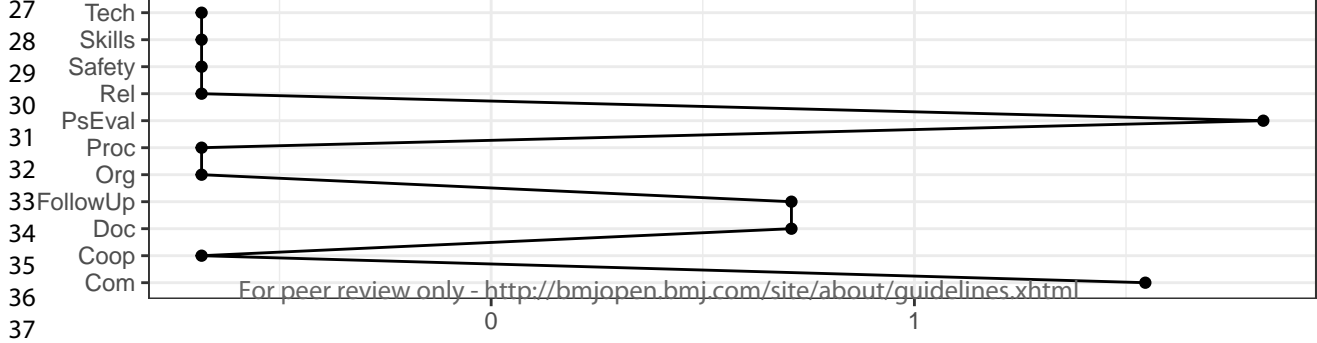
22

23

24

25

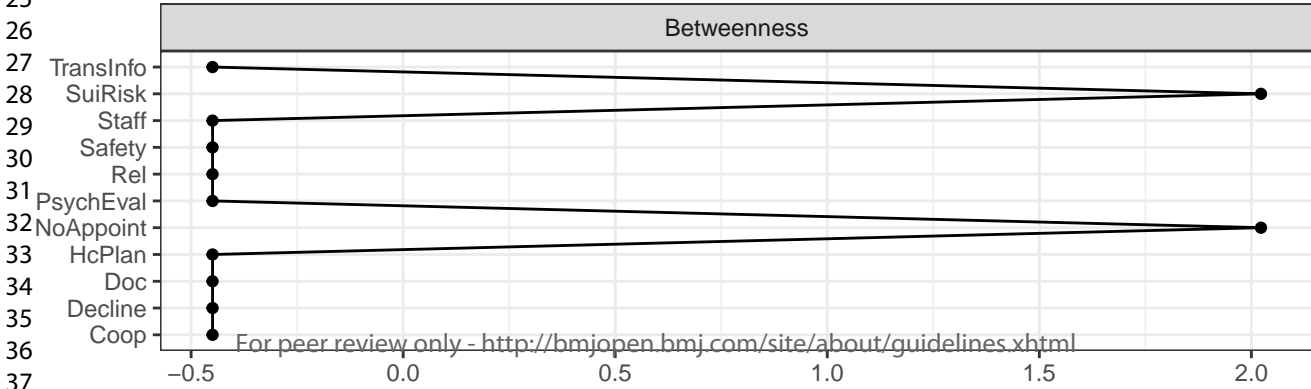
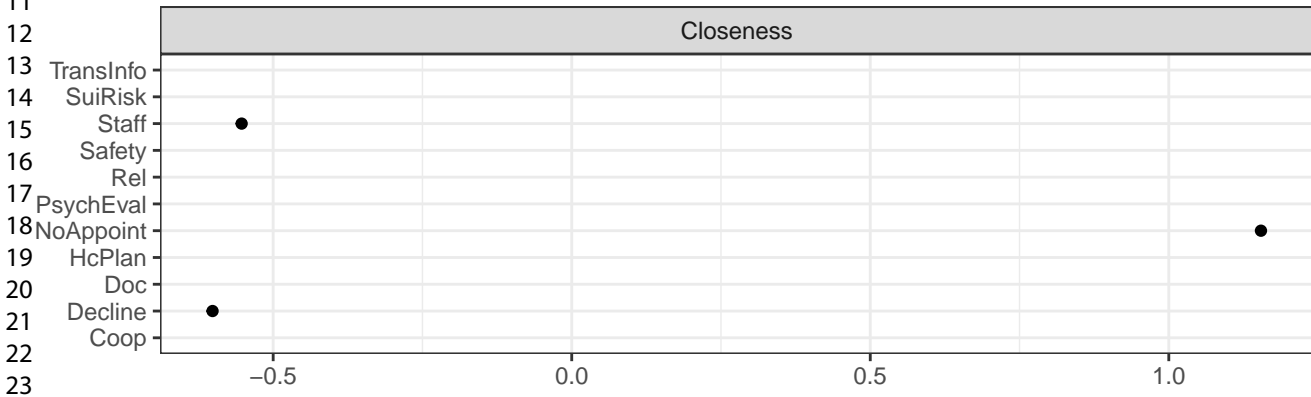
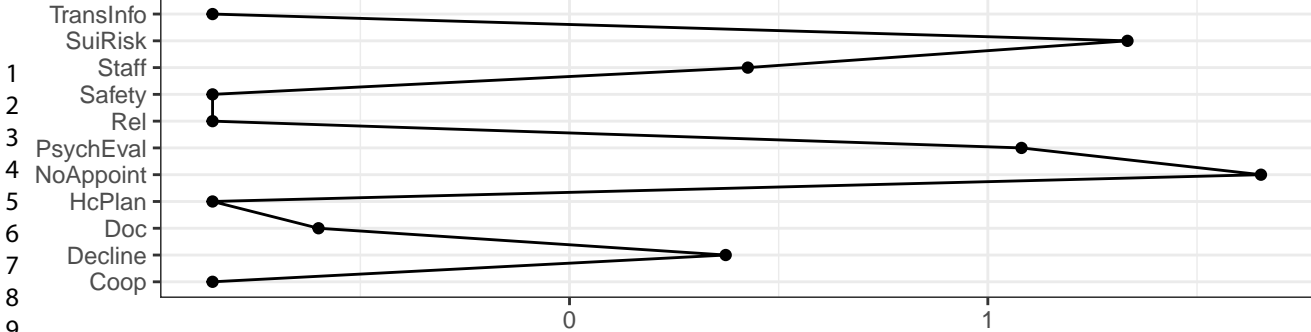
Betweenness



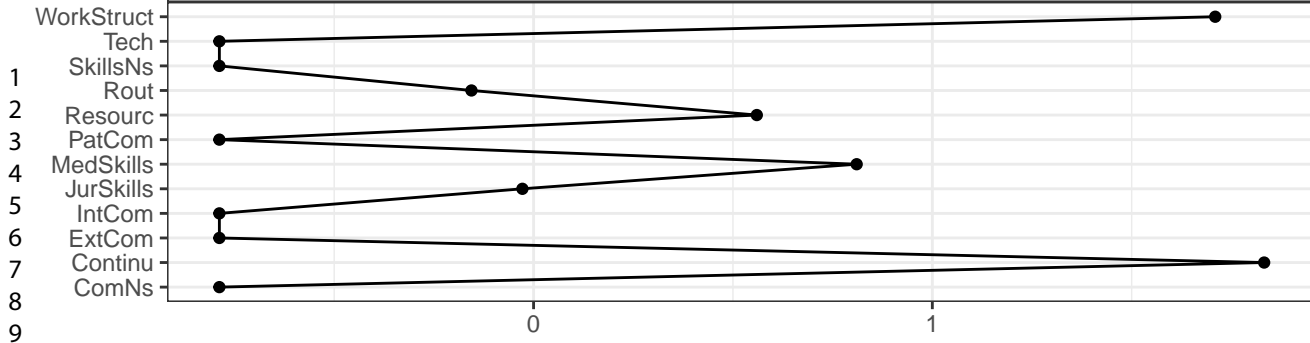
36

37

38



BM Open Influence



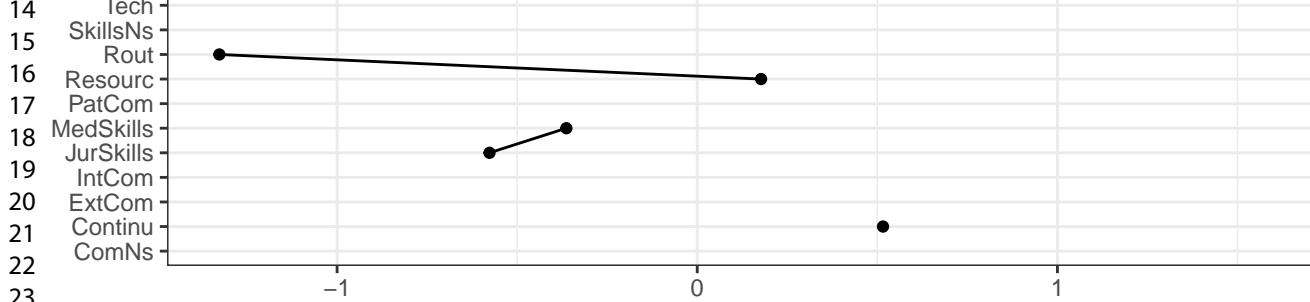
9

10

11

12

Closeness



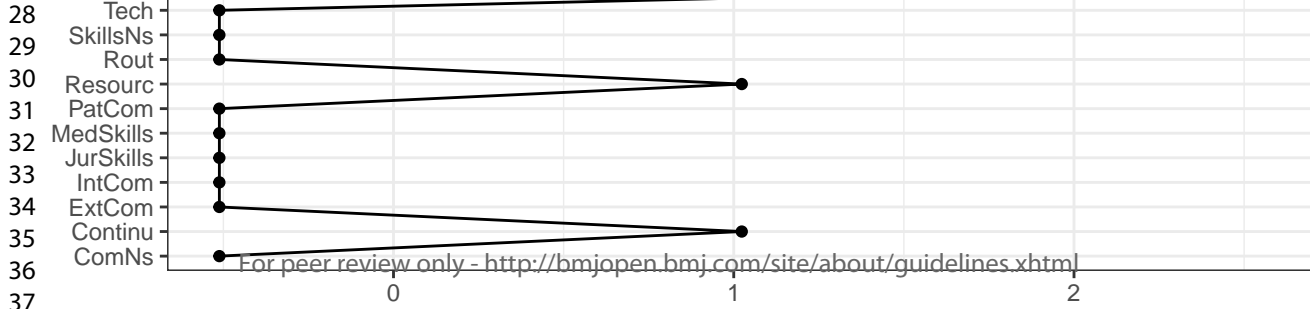
23

24

25

26

Betweenness



36

37

38

BMJ Open

Coexisting service-related factors preceding suicide: a network analysis

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2021-050953.R2
Article Type:	Original research
Date Submitted by the Author:	23-Feb-2022
Complete List of Authors:	Rex, Malin; University of Gothenburg, Institute of Health and Care Sciences, Sahlgrenska Academy; Sahlgrenska University Hospital, Affective clinic Brezicka, Thomas; Sahlgrenska University Hospital, Department for quality and patient safety Carlström, Eric; University of Gothenburg, Institute of Health and Care Sciences, Sahlgrenska Academy; University of Gothenburg, Centre for Person-Centred Care (GPCC) Waern, Margda; University of Gothenburg, Institute of Neuroscience and Physiology, Sahlgrenska Academy; Sahlgrenska University Hospital, Psychosis Clinic Ali, Lilas; University of Gothenburg, Institute of Health and Care Sciences, Sahlgrenska Academy; Sahlgrenska University Hospital, Affective Clinic
Primary Subject Heading:	Mental health
Secondary Subject Heading:	Mental health
Keywords:	Suicide & self-harm < PSYCHIATRY, PSYCHIATRY, Risk management < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Health & safety < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Organisational development < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

SCHOLARONE™
Manuscripts



I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our [licence](#).

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which [Creative Commons](#) licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

Coexisting service-related factors preceding suicide: a network analysis

Malin Rex^{1,2}, Thomas Brezicka⁴, Eric Carlström^{1,3}, Margda Waern^{5,6}, Lilas Ali^{1,2}.

¹ University of Gothenburg, Institute of Health and Care Sciences, Sahlgrenska Academy Gothenburg, Region Västra Götaland, Sweden

² Sahlgrenska University Hospital, Affective clinic Gothenburg, Region Västra Götaland, Sweden

³ University of Gothenburg, Centre for Person-Centred Care (GPCC) Gothenburg, Region Västra Götaland, Sweden

⁴ Sahlgrenska University Hospital, Department for quality and patient safety Gothenburg, Region Västra Götaland, Sweden

⁵ University of Gothenburg, Institute of Neuroscience and Physiology, Sahlgrenska Academy Gothenburg, Region Västra Götaland, Sweden

⁶ Sahlgrenska University Hospital, Psychosis Clinic Gothenburg, Region Västra Götaland, Sweden

Correspondence to: Malin Rex

POSTAL ADDRESS

University of Gothenburg, Institute of Health and Care Sciences
Box 457
405 30 Göteborg, Sweden

malin.rex@gu.se

+46-761199908

Keywords: Suicide, Patient safety, Network Analysis, Psychiatry, Mood disorders, Self-Injurious Behavior

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 organizational 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 organization; 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 organizational 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.

SUMMARY - STRENGTHS AND LIMITATIONS OF THIS STUDY

- The data source was based on standardized reports performed by trained healthcare teams.
- The data were examined and categorized by four professionals, experienced in performing and peer-reviewing RCA 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 were submitted to the national database.

BACKGROUND

Suicide is one of the leading causes of death worldwide, affecting people of all ages, socio-economic 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 behavior, 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]

Post-suicide 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 standardized 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, (2021).[15]

Network analysis is an approach to statistically analyse and visualize 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 multi-level 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 organizational risk factors, better communication among professionals, proper education and provision of adequate guidelines have been suggested.[15, 49, 52]

Previous studies based exclusively on post-suicide 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 belongingness,[74, 75] entrapment, hopelessness, and perceived burdensomeness[75, 77, 79, 81, 82] 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, 82, 83] Personalizing treatment strategies, for instance by using electronic devices for repeated ecological momentary assessment, has been suggested as an application of these findings.[73, 75, 84]

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 STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) checklist for reporting cross sectional studies (Supplement 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". [85] Information in NITHA is anonymized, 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 scrutinize 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. For two persons, gender was reported as "other." Men were slightly overrepresented. Mood disorders were recorded as the most common type of primary diagnosis for both sexes. Approximately half were between the ages of 18 and 49, and half were in contact with psychiatric services at time of death. Mood disorders were recorded as the most common type of primary diagnosis for both sexes.

Table 1. Patient demographics as reported to NITHA

	Total N = 217	Men n = 125	Women n = 90
NUMBER 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 data/omitted	43	22	21

Data extraction and processing

A data coding tool was developed to organize 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 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,

1
2
3 deficiencies are termed *adverse events*, and contributing factors *root causes*. Examples of typical
4 cases are reported for each category in Table 2. While some minor misclassifications in the original
5 data were noted by the research teams, terminology used in the original NITHA reports (including
6 definition of missing data) was retained.
7
8
9

10 In the original RCA reports each item could be reported multiple times. The range for some items
11 varied from 1 to 6, depending on whether the RCA team had registered deficiencies in a merged or
12 split form. To avoid skewed results, all observations were binarized (using the simple algorithm “IF
13 count value ≥ 0 , THEN 1, ELSE 0”) before being entered into the network model.
14
15
16

17 18 **Data analysis**

19
20 The synthesized network model contains two elements: nodes (sometimes called vertices),
21 representing variables, and edges (also called links) which represent pairwise association among
22 nodes.[16, 82] The network can be either directed, displaying the influential effect from one node to
23 another, or undirected, where mutual influences are indicated by a line between two nodes without
24 any direction.[16] Centrality indices, such as strength, betweenness and expected influence, are
25 employed to evaluate the network.[16, 86] An overview of different types of networks and applicable
26 models has been published by Hevey, 2018.[23] For a further discussion on psychometrics and
27 network estimation, we refer to previous researchers in this field.[31, 87-91]
28
29
30
31
32
33

34 Three networks were produced: one giving an overview of the major themes (Figure 1-2), another
35 showing subthemes of deficiencies (Figure 3-4) and a third covering subthemes of contributing
36 factors (Supplement B). Frequencies and percentages are reported for each variable (Table 2),
37 alongside the centrality indices and stability measures (Figure 1-2). Data were analysed using IBM
38 Statistical Package for the Social Sciences version 25 and R version 3.5.0 (bootnet package version
39 1.4.3, ggplot2 version 3.3.5, igraph package version 1.2.6, qgraph package version 1.6.9, IsingFit
40 package version 0.3.1).[92-98] To visualize the dependencies, we used an undirected network
41 (formally called a pairwise Markov random field).[28, 88, 99] Relevant relationships among nodes
42 were estimated using IsingFit package which uses an enhanced least absolute shrinkage and selection
43 operator (eLASSO), based on the Ising Model. The operator reduces spurious edges by suppressing
44 minimal connections to exactly zero. Selection is performed by combining logistic regression (ℓ_1 -
45 regularized) and a model selection based on the Extended Bayesian Information Criterion (EBIC).[97]
46 Since the network structures were sparse, the EBIC hyperparameter (γ) was adjusted to 0 after
47 careful consideration and comparisons of different settings. A γ set to 0 (can vary from 0 to 1, default
48 is 0.25) results in a lower shrinkage of estimated connections. As simulation studies have shown, the
49 likelihood of false positives is low and the specificity will still be higher compared to a non-
50
51
52
53
54
55
56
57
58
59
60

1
2
3 regularized partial correlation network.[23, 89, 100] The estimated networks were then
4 bootstrapped for accuracy and stability using the bootnet function, which performs a non-parametric
5 bootstrap to calculate the 95% bootstrapped confidence intervals (CIs) for the edges by resampling
6 the data with replacement 2500 times per network. The networks were visualised with the plotting
7 tools in qgraph, using the force directed layout “spring”, which employs the Fruchterman-Reingold
8 algorithm and draws nodes with higher centrality towards the center.[94, 101] Lastly, network
9 communities were calculated using the walktrap algorithm and plotted with igraph, qgraph and
10 ggplot2 plotting tools.[93, 95, 98] The data and R code necessary to reproduce our results can be
11 found on The Open Science Framework repository.[102-105]
12
13
14
15
16
17
18

19 **Patient and public involvement**

20 Neither patients nor the public were involved in this study.
21
22

23 **RESULTS**

24 **Frequencies and percentages of reported variables**

25
26
27
28 Frequencies and percentages for identified categories of deficiencies and contributing factors are
29 reported in Table 2.
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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)

1	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)
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)
3	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)
4										JurSkills	Lack of competence regarding juridical or organizational matters	Regulations regarding <i>The Compulsory Mental Care Act</i> (Swedish law 1991:1128) were not applied appropriately.	17 (4)
5										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)
6										Tech	Technical equipment and systems (n = 15)	Tech	Malfunctional design of devices or rooms
7	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)						
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													
22													
23													
24													
25													
26													
27													
28													
29													
30													
31													
32													
33													
34													
35													
36													
37													
38													
39													
40													
41													
42													
43													
44													
45													
46													

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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 27 percent of the cases involving follow-up, healthcare planning that could have provided a framework for treatment during the transition was also lacking. 76 percent 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 15 percent 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 organizational 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.[88, 106] The CS-coefficients for each of the three networks (the major network, Deficiencies network, and Contributing factors network) are shown 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. [88] The visualization of this network is included in Supplement B, along with the centrality indices calculated for this subset.

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

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 regularized network reflects the magnitude of the pairwise relationship between two nodes, while controlling for indirect influences via other nodes.[23, 89] The centrality indices closeness, betweenness and expected influence (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 Supplement C-E.

[Please insert Figure 1 here.]

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

[Please insert Figure 2 here.]

As shown in both Figure 1 and Figure 2, nodes representing documentation, communication, organization, follow-up, procedures and psychiatric evaluation were central, compared to 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 negative connections were found: 1) between organization and communication, and 2) between psychiatric evaluation and procedures, which may reflect how data were registered by the RCA teams.

[Please insert Figure 3 here.]

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.

[Please insert Figure 4 here.]

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

1
2
3 plan being either absent or incomplete, and assessment not being recorded were more peripheral
4 (Figure 4.)
5

6
7 The third network, representing contributing factors, was too instable to estimate. Although the
8 nodes for work structure, resources, competence, and continuity had the highest node strength
9 centrality, the differences were not significant. Our recommendations are to examine these more
10 thoroughly in a future study with a larger sample. The topology and centrality indices for the
11 Contributing factors network are shown in Supplement B.
12
13
14

15 16 **Detected communities**

17 Communities were detected using the walktrap algorithm.[93] The nodes belonging to a community
18 are color marked in the visualizations of the networks in Figure 1 and Figure 2.
19

20
21
22 Two communities were present in the major network (Figure 1):
23

24 1) the nodes for the deficiencies psychiatric evaluation, follow-up, and the contributing factor for
25 procedures, routines, and policies.
26

27
28 2) the nodes for the deficiency communication and the nodes representing the contributing factors
29 organization and communication.
30

31
32 Analysis of the Deficiencies network (Fig. 2) resulted in two detected communities. The first included
33 the nodes representing understaffing, declined/missed appointments, and cases where future
34 appointments had not been booked. The second covered the nodes representing assessments of
35 suicide risk and of the overall mental condition.
36
37
38

39 40 **DISCUSSION**

41 The results of this study suggest that reported adversities are linked to a group of activities, rather
42 than to single mistakes. Providing suicidal patients with regular assessments, for instance, and
43 proposing adequate actions depends not only on the personal conditions of the evaluating clinician
44 and the patient being assessed, but also on proper work structures, good intrateam communication,
45 adequate routines and well-known procedures, and sufficient documentation of planned and
46 performed activities.
47
48
49

50
51
52 There are three main findings of this study. First, missed and declined appointments are central
53 features when examining elements occurring prior to the suicide. Together they account for a fifth of
54 the total amount of deficiencies. We have not examined the positive effects of feedback loop
55 systems which enhances the ability for healthcare providers to react when a patient does not turn up
56 on scheduled meetings. Nor have we investigated cases with negative correlations between
57
58
59
60

1
2
3 treatment cancellations and suicide. However, one hypothesis drawn from our results and
4 extrapolated conclusions from previous studies,[51, 52, 57, 58, 60-63, 65-72] is that any disruption in
5 treatment is negative, and cancellations made by the patient could be an early warning sign of an
6 ongoing exacerbation of the suicidal process. During phases of acute suicidality or in the early stages
7 of recovery from a suicide attempt, the wellbeing of the patient is frail, and the suicide risk may
8 fluctuate rapidly.[58, 61, 64-66] Establishing a backup system, which safeguards follow-up plans and
9 alerts healthcare staff when patients cancel planned appointments, could help improve patient
10 safety. Second, many nodes are still disconnected. Even if it is likely that there is an underlying
11 covariance, the correlation is not independently significant. The sparsity of the networks could be
12 explained by the estimation procedure. Each network has been regularized to reduce false positive
13 connections and produce parsimonious graphs. When comparing them with networks based on
14 partial correlation matrices, many edges have been omitted due to the penalization. It is therefore
15 likely that other patterns would appear if more data were entered. Third, the nodes representing
16 security, technical issues and contact with relatives have both low frequencies and low centrality.
17 This means that adversities related to these areas are rarely reported. One reason for this can be the
18 very nature of the type of failures that can occur in these areas. Denied access to an important
19 medical record system at a specific time rarely affects more than one or a few team members at a
20 time. Ligature points, once removed, do not reappear at the exact same location. Establishing and
21 maintaining stable work conditions, on the other hand, is more elusive. The concept of organizational
22 prerequisites to provide safe interventions to suicidal patients is subjective which could lead to a
23 higher rate of recurrences of management related issues. While adverse events concerning security
24 at the inpatient facilities were rare, the transition to outpatient services was frequently mentioned in
25 the post-mortem audits. Transitions imply a change in primary caregiver and a shift from short-term
26 to long-term treatment goals. A connection to elevated risk levels could be expected, although the
27 direct relationship has not been investigated in this study. To gain more knowledge about the
28 mechanisms involved, network studies covering these steps of the process are needed. Even though
29 interviews with relatives were included in 64 % of the reports, their perspective were only reflected
30 in 1 % of the deficiencies (Table 2). This situation has been previously described by Bouwman et al.
31 (2018). After examining policies from 15 healthcare organizations and spoken to 35 stakeholders
32 (including patient, families and their counsellors, national regulators and professionals) they
33 concluded that involvement by relatives, insofar they had been involved, rarely extended beyond
34 aftercare and information provision.[50] With this in mind, studies based on the narratives of
35 relatives would probably complement and enrich our results.
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3 We acknowledge that from a general point of view, some of our findings are similar to the
4 conclusions drawn by our colleagues in the same field. Suicide risk is multifactorial, and decisions
5 about appropriate safety measures are dependent on factors on both individual and structural
6 levels.[5, 6, 10, 38, 40, 42, 44, 46, 48, 49, 51, 53-55, 57, 58, 60-64, 66, 68-70] However, following the
7 argumentation of Fried and Robinaugh (2021) on complexity, adverse events cannot be prevented by
8 understanding the single components alone, neglecting the interactions among them.[107] If the
9 value of a unique node is determined not only by the intrinsic properties of the node itself, but by its
10 relations to other objects, the study of single factors will not yield any ultimate answers about how
11 to prevent undesired events. To gain more knowledge, we must first examine the dynamics of the
12 systems from which adversity arises.

21 CONCLUSION

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

35 STRENGTHS AND LIMITATIONS

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

42 The study also has several limitations. This was a cross-sectional study, limiting the capacity to
43 identify the directions of effects. Since we obtained our data exclusively through the NITHA system,
44 other post-suicide investigations were not included. Because regional institutional praxis concerning
45 submission to the NITHA database varied, RCA reports cannot be considered representative for the
46 country of Sweden. A relatively small proportion of all suicides were submitted to the database, and
47 therefore selection bias cannot be ruled out. The RCA methodology is designed to scrutinize
48 organizations and detect possible causes for systematic negative output. Consequently, the reported
49 findings may focus on incidental discoveries, rather than some latent factor which lies beyond the
50
51
52
53
54
55
56
57
58
59
60

1
2
3 scope of the protocol. Moreover, since RCA aims to identify organizational vulnerabilities, the reports
4 lack certain details concerning the patients themselves. As we did not have access to original records,
5 we have not been able to verify the accuracy of the content in the RCA reports. Therefore, our
6 findings will reflect any misclassification done by the RCA teams during the initial investigation
7 process. Lastly, the classification tool used by the auditing teams has not been validated by
8 independent reviewers. The data were qualitatively categorized and could have been organized
9 differently.
10
11
12
13
14
15

16 **FUTURE RESEARCH**

17 Based on the findings of this study, we suggest further research on security systems which help
18 healthcare providers to react when patients drop out of treatment. Considering the relatively low
19 number of observations, we also recommend future network studies based on a larger sample. To
20 gain more insights into the perspectives of patients and relatives, network studies based on their
21 experiences would be a fruitful approach.
22
23
24
25

26 **ACKNOWLEDGEMENTS**

27 The authors would like to express their gratitude to Cecilia Boldt-Christmas, Marzia Dellepiane, and
28 Evalena von Hausswolff who participated in the data extraction and coding.
29
30
31

32 **CONTRIBUTORS**

33 MR designed the study, collected and registered the data, performed the analyses, and drafted the
34 manuscript. EC, LA, MW, and TB contributed to the study design, analyses, and manuscript revision.
35 All authors read and approved the final manuscript.
36
37
38
39

40 **COMPETING INTERESTS**

41 There are no competing interests for any author.
42
43
44
45

46 **FUNDING**

47 This work was supported by the Affective Clinic, Sahlgrenska University Hospital, Gothenburg, Region
48 Västra Götaland (no specific grant number).
49
50
51

52 **DATA AVAILABILITY STATEMENT**

53 Copies of used R scripts and data sets can be found in our repository at Open Science Framework:
54 DOI 10.17605/OSF.IO/3DHTF
55
56
57
58
59
60

ETHICAL REVIEW

According to the Swedish Act Concerning the Ethical Review of Research Involving Humans (2003:460), this study did not require ethical review as it did not involve living human participants.

For peer review only

REFERENCES

1. World Health Organization. Suicide worldwide in 2019: global health estimates. Geneva: World Health Organization; 2021. Available from: <https://www.who.int/publications/i/item/9789240026643> (accessed October 19, 2021).
2. World Health Organization. Preventing suicide: a global imperative. 2014. Available from: http://apps.who.int/iris/bitstream/handle/10665/131056/9789241564779_eng.pdf?sequence=1 (accessed January 19, 2019).
3. Ropper AH, Fazel S, Runeson B. Suicide. *The New England Journal of Medicine*. 2020;382(3):266-74.
4. Too LS, Spittal MJ, Bugeja L, et al. The association between mental disorders and suicide: A systematic review and meta-analysis of record linkage studies. *J Affect Disord*. 2019;259:302-13.
5. Runeson B, Haglund A, Lichtenstein P, et al. Suicide risk after nonfatal self-harm: a national cohort study, 2000-2008. *J Clin Psychiatry*. 2016;77(2):240-6.
6. Large M, Sharma S, Cannon E, et al. Risk Factors for Suicide Within a Year of Discharge from Psychiatric Hospital: A Systematic Meta-Analysis. *Aust N Z J Psychiatry*. 2011;45(8):619-28.
7. Waern M, Kaiser N, Renberg ES. Psychiatrists' experiences of suicide assessment. *BMC Psychiatry*, 2016, Vol 16. 2016;16.
8. Steeg S, Quinlivan L, Nowland R, et al. Accuracy of risk scales for predicting repeat self-harm and suicide: a multicentre, population-level cohort study using routine clinical data.(Report). *BMC Psychiatry*. 2018;18(1).
9. Smith MJ, Bouch J, Bradstreet S, et al. Health services, suicide, and self-harm: patient distress and system anxiety. *Lancet Psychiatry*. 2015;2(3):275-80.

10. Hoffmire C, Stephens B, Morley S, et al. VA Suicide Prevention Applications Network: A National Health Care System–Based Suicide Event Tracking System. *Public Health Rep.* 2016;131(6):816-21.
11. Clarke I. Learning from critical incidents. *Advances in Psychiatric Treatment.* 2018;14(6):460-8.
12. Ericsson C, Hessel Å. *Risikanalys och händelseanalys: analysmetoder för att öka patientsäkerheten : handbok* [Risk analysis and Root Cause Analysis: analysis methods to improve patient safety: handbook]. Stockholm: Sveriges kommuner och landsting; 2015. Available from: <http://webbutik.skl.se/sv/artiklar/risikanalys-och-handelseanalys-analysmetoder-for-att-oka-patientsakerheten.html> (accessed October 19, 2021).
13. Bowie P, Skinner J, de Wet C. Training health care professionals in root cause analysis: a cross-sectional study of post-training experiences, benefits and attitudes. *BMC Health Serv Res.* 2013;13:50-.
14. Aboumradi M, Neily J, Watts BV. Teaching Root Cause Analysis Using Simulation: Curriculum and Outcomes. *Journal of medical education and curricular development.* 2019;6:2382120519894270-.
15. Fröding E, Gäre BA, Westrin Å, et al. Suicide as an incident of severe patient harm: a retrospective cohort study of investigations after suicide in Swedish healthcare in a 13-year perspective. *BMJ Open.* 2021;11(3):e044068.
16. Newman M. *Networks.* Oxford: Oxford: Oxford University Press; 2018.
17. Luke DA, Harris JK. Network Analysis in Public Health: History, Methods, and Applications. *Annu Rev Public Health.* 2007;28(1):69-93.
18. Borsboom D. Psychometric perspectives on diagnostic systems. *J Clin Psychol.* 2008;64(9):1089-108.
19. Borsboom D, Cramer AO. Network analysis: an integrative approach to the structure of psychopathology. *Annu Rev Clin Psychol.* 2013;9:91-121.

- 1
2
3
4 20. Schmittmann VD, Cramer AOJ, Waldorp LJ, et al. Deconstructing the
5
6 construct: A network perspective on psychological phenomena. *New*
7
8 *Ideas Psychol.* 2013;31(1):43-53.
- 9
10 21. van der Maas HL, Dolan CV, Grasman RP, et al. A dynamical model of
11
12 general intelligence: the positive manifold of intelligence by mutualism.
13
14 *Psychol Rev.* 2006;113(4):842-61.
- 15
16 22. Cramer AOJ, Waldorp LJ, van der Maas HLJ, et al. Comorbidity: A
17
18 network perspective. *The Behavioral and brain sciences.* 2010;33(2-
19
20 3):15-150.
- 21
22 23. Hevey D. Network analysis: a brief overview and tutorial. *Health*
23
24 *Psychology and Behavioral Medicine.* 2018;6(1):301-28.
- 25
26 24. Beard C, Millner A, Forgeard M, et al. Network analysis of depression
27
28 and anxiety symptom relationships in a psychiatric sample. *Psychol*
29
30 *Med.* 2016;46(16):3359-69.
- 31
32 25. Fried EI, van Borkulo CD, Cramer AOJ, et al. Mental disorders as
33
34 networks of problems: a review of recent insights. *Soc Psychiatry*
35
36 *Psychiatr Epidemiol.* 2017;52(1):1-10.
- 37
38 26. Fried EI, Bockting C, Arjadi R, et al. From Loss to Loneliness: The
39
40 Relationship Between Bereavement and Depressive Symptoms. *Journal*
41
42 *of abnormal psychology (1965).* 2015;124(2):256-65.
- 43
44 27. Borsboom D, Cramer AOJ, Schmittmann VD, et al. The small world of
45
46 psychopathology. *PLoS One.* 2011;6(11):e27407-e.
- 47
48 28. Borsboom D, Deserno MK, Rhemtulla M, et al. Network analysis of
49
50 multivariate data in psychological science. *Nature Reviews Methods*
51
52 *Primers.* 2021;1(1):58.
- 53
54 29. Bringmann LF, Lemmens LHJM, Huibers MJH, et al. Revealing the
55
56 dynamic network structure of the Beck Depression Inventory-II. *Psychol*
57
58 *Med.* 2015;45(4):747-57.
- 59
60

- 1
2
3
4 30. Costantini G, Epskamp S, Borsboom D, et al. State of the aRt
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
31. Costantini G, Richetin J, Preti E, et al. Stability and variability of
personality networks. A tutorial on recent developments in network
psychometrics. *Pers Individ Dif*. 2019;136:68-78.
32. Cramer AOJ, van der Sluis S, Noordhof A, et al. Dimensions of Normal
Personality as Networks in Search of Equilibrium: You Can't Like Parties
if You Don't Like People. *European Journal of Personality*.
2012;26(4):414-31.
33. Forkmann T, Teismann T, Stenzel J-S, et al. Defeat and entrapment:
more than meets the eye? Applying network analysis to estimate
dimensions of highly correlated constructs.(Report). *BMC Med Res
Methodol*. 2018;18(1).
34. Richetin J, Preti E, Costantini G, et al. The centrality of affective
instability and identity in Borderline Personality Disorder: Evidence from
network analysis. *PLoS One*. 2017;12(10).
35. Isvoranu A-M, Abidin E, Chong SA, et al. Extended network analysis:
from psychopathology to chronic illness. *BMC Psychiatry*.
2021;21(1):119-.
36. Isvoranu A-M, van Borkulo CD, Boyette L-L, et al. A Network Approach
to Psychosis: Pathways Between Childhood Trauma and Psychotic
Symptoms. *Schizophr Bull*. 2017;43(1):187-96.
37. Köhne ACJ, Isvoranu A-M. A Network Perspective on the Comorbidity of
Personality Disorders and Mental Disorders: An Illustration of
Depression and Borderline Personality Disorder. *Front Psychol*.
2021;12:680805-.
38. Cheng A, Chen T, Chen CC, et al. Psychosocial and psychiatric risk
factors for suicide: case-control psychological autopsy study. *Br J
Psychiatry*. 2000(177):360-5.

- 1
2
3
4 39. Berman AL, Silverman MM. Suicide Risk Assessment and Risk
5 Formulation Part II : Suicide Risk Formulation and the Determination of
6 Levels of Risk. *Suicide and Life-Threatening Behavior*. 2014;44(4):432-
7 43.
8
9
- 10
11 40. Pirkis J, Too LS, Spittal MJ, et al. Interventions to reduce suicides at
12 suicide hotspots: a systematic review and meta-analysis. *Lancet*
13 *Psychiatry*. 2015;2(11):994-1001.
14
15
- 16 41. Barker E, Kolves K, De Leo D. Rail-suicide prevention: Systematic
17 literature review of evidence-based activities. *Asia-Pacific Psychiatry*.
18 2017;9(3):e12246.
19
20
- 21 42. Zalsman G, Hawton K, Wasserman D, et al. Suicide prevention
22 strategies revisited: 10-year systematic review. *Lancet Psychiatry*.
23 2016;3(7):646-59.
24
25
- 26 43. Zalsman G, Hawton K, Wasserman D, et al. Evidence-based national
27 suicide prevention taskforce in Europe: A consensus position paper. *Eur*
28 *Neuropsychopharmacol*. 2017;27(4):418-21.
29
30
- 31 44. Mann JJ, Apter A, Bertolote J, et al. Suicide prevention strategies: a
32 systematic review. *JAMA*. 2005;294(16):2064-74.
33
34
- 35 45. Vine R, Mulder C. After an inpatient suicide: the aim and outcome of
36 review mechanisms. *Australasian Psychiatry*. 2013;21(4):359-64.
37
38
- 39 46. Meerwijk EL, Parekh A, Oquendo MA, et al. Direct versus indirect
40 psychosocial and behavioural interventions to prevent suicide and
41 suicide attempts: a systematic review and meta-analysis. *Lancet*
42 *Psychiatry*. 2016;3(6):544-54.
43
44
- 45 47. Sakashita T, Oyama H. Overview of community-based studies of
46 depression screening interventions among the elderly population in
47 Japan. *Aging Ment Health*. 2016;20(2):231-9.
48
49
- 50 48. Cole-King A, Parker V, Williams H, et al. Suicide prevention: are we
51 doing enough? *Advances in Psychiatric Treatment*. 2018;19(4):284-91.
52
53
54
55
56
57
58
59
60

- 1
2
3
4 49. Huisman A, Kerkhof AJFM, Robben PBM. Suicides in users of mental
5 health care services: treatment characteristics and hindsight reflections.
6
7 *Suicide Life Threat Behav.* 2011;41(1):41.
- 8
9 50. Bouwman R, De Graaff B, De Beurs D, et al. Involving Patients and
10 Families in the Analysis of Suicides, Suicide Attempts, and Other
11 Sentinel Events in Mental Healthcare: A Qualitative Study in The
12 Netherlands. *Int J Environ Res Public Health.* 2018;15(6):1104.
- 13
14 51. Burgess P, Pirkis J, Morton J, et al. Lessons From a Comprehensive
15 Clinical Audit of Users of Psychiatric Services Who Committed Suicide.
16
17 *Psychiatr Serv.* 2000;51(12):1555-60.
- 18
19 52. Roos af Hjelmsäter E, Ros A, Gäre BA, et al. Deficiencies in healthcare
20 prior to suicide and actions to deal with them: a retrospective study of
21 investigations after suicide in Swedish healthcare. *BMJ Open.*
22
23 2019;9(12):e032290.
- 24
25 53. Large M, Smith G, Sharma S, et al. Systematic review and meta-
26 analysis of the clinical factors associated with the suicide of psychiatric
27 in-patients. *Acta Psychiatr Scand.* 2011;124(1):18-9.
- 28
29 54. Meehan J, Kapur N, Hunt I, et al. Suicide in Mental Health In-Patients
30 and within 3 Months of Discharge. *The British Journal of Psychiatry.*
31
32 2006;188(2):129-34.
- 33
34 55. Changchien T-C, Yen Y-C, Wang Y-J, et al. Establishment of a
35 Comprehensive Inpatient Suicide Prevention Network by Using Health
36 Care Failure Mode and Effect Analysis. *Psychiatr Serv.* 2019;70(6):518-
37
38 21.
- 39
40 56. Williams SC, Schmaltz SP, Castro GM, et al. Incidence and Method of
41 Suicide in Hospitals in the United States. *The Joint Commission Journal*
42
43 *on Quality and Patient Safety.* 2018;44(11):643-50.
- 44
45 57. Iliachenko EK, Ragazan DC, Eberhard J, et al. Suicide mortality after
46 discharge from inpatient care for bipolar disorder: A 14-year Swedish
47 national registry study. *J Psychiatr Res.* 2020;127:20-7.
- 48
49
50
51
52
53
54
55
56
57
58
59
60

- 1
2
3
4 58. Haglund A, Lysell H, Larsson H, et al. Suicide Immediately After
5 Discharge From Psychiatric Inpatient Care: A Cohort Study of Nearly 2.9
6 Million Discharges. *The Journal of clinical psychiatry*. 2019;80(2).
7
8
9 59. Appleby L, Dennehy JA, Thomas CS, et al. Aftercare and clinical
10 characteristics of people with mental illness who commit suicide: a case-
11 control study. *The Lancet*. 1999;353(9162):1397-400.
12
13 60. Qin P, Nordentoft M. Suicide Risk in Relation to Psychiatric
14 Hospitalization: Evidence Based on Longitudinal Registers. *JAMA*
15 *Psychiatry*. 2005;62(4):427-32.
16
17 61. Chung D, Hadzi-Pavlovic D, Wang M, et al. Meta-analysis of suicide
18 rates in the first week and the first month after psychiatric
19 hospitalisation. *BMJ Open*. 2019;9(3).
20
21 62. Riblet VN, Shiner RB, Watts RB, et al. Death by Suicide Within 1 Week
22 of Hospital Discharge: A Retrospective Study of Root Cause Analysis
23 Reports. *The Journal of Nervous and Mental Disease*. 2017;205(6):436-
24 42.
25
26 63. Valenstein M, Kim HM, Ganoczy D, et al. Higher-risk periods for suicide
27 among VA patients receiving depression treatment: Prioritizing suicide
28 prevention efforts. *J Affect Disord*. 2009;112(1):50-8.
29
30 64. Bickley H, Hunt IM, Windfuhr K, et al. Suicide Within Two Weeks of
31 Discharge From Psychiatric Inpatient Care: A Case-Control Study.
32 *Psychiatr Serv*. 2013;64(7):653-9.
33
34 65. Appleby L, Dennehy JA, Thomas CS, et al. Aftercare and clinical
35 characteristics of people with mental illness who commit suicide: a case-
36 control study. *The Lancet (British edition)*. 1999;353(9162):1397-400.
37
38 66. Chung DT, Ryan CJ, Hadzi-Pavlovic D, et al. Suicide Rates After
39 Discharge From Psychiatric Facilities: A Systematic Review and Meta-
40 analysis
41 Suicide Rates After Discharge From Psychiatric Facilities
42 Suicide Rates After Discharge From Psychiatric Facilities. *JAMA Psychiatry*.
43 2017;74(7):694-702.
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

- 1
2
3
4 67. Gillies D, Chicop D, O'Halloran P. Root Cause Analyses of Suicides of
5 Mental Health Clients. *Crisis: The Journal of Crisis Intervention and*
6 *Suicide Prevention*. 2015;36(5):316-24.
7
8
9 68. Mills PD, Gallimore BI, Watts BV, et al. Suicide attempts and
10 completions in Veterans Affairs nursing home care units and long-term
11 care facilities: a review of root-cause analysis reports. *Int J Geriatr*
12 *Psychiatry*. 2016;31(5):518-25.
13
14 69. Mills PD, Huber SJ, Vince Watts B, et al. Systemic vulnerabilities to
15 suicide among veterans from the Iraq and Afghanistan Conflicts: review
16 of case reports from a National Veterans Affairs Database. *Suicide Life*
17 *Threat Behav*. 2011;41(1):21-32.
18
19 70. Mills PD, Neily J, Luan D, et al. Actions and implementation strategies to
20 reduce suicidal events in the Veterans Health Administration. *Jt Comm J*
21 *Qual Patient Saf*. 2006;32(3):130-41.
22
23 71. Mills PD, Watts BV, Shiner B, et al. Adverse events occurring on mental
24 health units. *Gen Hosp Psychiatry*. 2018;50:63-8.
25
26 72. Aboumrad M, Shiner B, Riblet N, et al. Factors contributing to cancer-
27 related suicide: A study of root-cause analysis reports. *Psychooncology*.
28 2018;27(9):2237-44.
29
30 73. de Beurs D. Network Analysis: A Novel Approach to Understand
31 Suicidal Behaviour. *Int J Environ Res Public Health*. 2017;14(3):219.
32
33 74. Gijzen MWM, Rasing SPA, Creemers DHM, et al. Suicide ideation as a
34 symptom of adolescent depression. a network analysis. *J Affect Disord*.
35 2021;278:68-77.
36
37 75. Rath D, de Beurs D, Hallensleben N, et al. Modelling suicide ideation
38 from beep to beep: Application of network analysis to ecological
39 momentary assessment data. *Internet Interventions*. 2019;18:100292.
40
41 76. Shiratori Y, Tachikawa H, Nemoto K, et al. Network analysis for motives
42 in suicide cases: A cross-sectional study. *Psychiatry Clin Neurosci*.
43 2014;68(4):299-307.
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

- 1
2
3
4 77. De Beurs D, Fried EI, Wetherall K, et al. Exploring the psychology of
5 suicidal ideation: A theory driven network analysis. *Behav Res Ther.*
6 2019;120:103419.
7
8
9 78. Núñez D, Ulloa JL, Guillaume S, et al. Suicidal ideation and affect lability
10 in single and multiple suicidal attempters with Major Depressive
11 Disorder: An exploratory network analysis. *J Affect Disord.*
12 2020;272:371-9.
13
14
15
16 79. Bloch-Elkouby S, Gorman B, Schuck A, et al. The Suicide Crisis
17 Syndrome: A Network Analysis. *J Couns Psychol.* 2020;67(5):595-607.
18
19
20 80. Núñez D, Fresno A, van Borkulo CD, et al. Examining relationships
21 between psychotic experiences and suicidal ideation in adolescents
22 using a network approach. *Schizophr Res.* 2018;201:54-61.
23
24
25
26 81. De Beurs D, Fried EI, Wetherall K, et al. Exploring the psychology of
27 suicidal ideation: A theory driven network analysis. *Behaviour research*
28 *and therapy.* 2019;120.
29
30
31
32 82. de Beurs D, Vancayseele N, van Borkulo C, et al. The association
33 between motives, perceived problems and current thoughts of self-harm
34 following an episode of self-harm. A network analysis. *J Affect Disord.*
35 2018;240:262-70.
36
37
38
39 83. Simons JS, Simons RM, Walters KJ, et al. Nexus of despair: A network
40 analysis of suicidal ideation among veterans. *Archives of suicide*
41 *research.* 2020;24(sup1):314-36.
42
43
44
45 84. de Beurs DP, van Borkulo CD, O'Connor RC. Association between
46 suicidal symptoms and repeat suicidal behaviour within a sample of
47 hospital-treated suicide attempters. *BJPsych Open.* 2017;3(3):120-6.
48
49
50 85. Inera. *Nationellt IT-stöd för händelseanalyser - NITHA Kunskapsbank*
51 [National database for root cause analyses]. October 19, 2021.
52 Available from: <https://nitha.inera.se/Learn>.
53
54
55
56
57
58
59
60

- 1
2
3
4 86. Bringmann LF, Elmer T, Epskamp S, et al. What do centrality measures
5 measure in psychological networks? *J Abnorm Psychol*.
6 2019;128(8):892-903.
7
8
9 87. Williams DR, Rhemtulla M, Wysocki AC, et al. On Nonregularized
10 Estimation of Psychological Networks. *Multivariate Behavioral*
11 *Research*. 2019;54(5):719-50.
12
13
14 88. Epskamp S, Borsboom D, Fried EI. Estimating psychological networks
15 and their accuracy: A tutorial paper. *Behav Res Methods*.
16 2018;50(1):195-212.
17
18
19 89. Epskamp S, Fried EI. A Tutorial on Regularized Partial Correlation
20 Networks. *Psychol Methods*. 2018;23(4):617-34.
21
22
23 90. Epskamp S, Waldorp LJ, Möttus R, et al. The Gaussian Graphical Model
24 in Cross-Sectional and Time-Series Data. *Multivariate behavioral*
25 *research*. 2018;53(4):453-80.
26
27
28 91. Robinaugh DJ, Millner AJ, McNally RJ. Identifying highly influential
29 nodes in the complicated grief network. *J Abnorm Psychol*.
30 2016;125(6):747-57.
31
32
33 92. van Borkulo C, Epskamp, S., & Robitzsch, A. IsingFit: Fitting Ising
34 Models Using the Elasso Method. 2016. Available from: [https://CRAN.R-](https://CRAN.R-project.org/package=IsingFit)
35 [project.org/package=IsingFit](https://CRAN.R-project.org/package=IsingFit).
36
37
38 93. Csardi GN, T. The igraph software package for complex network
39 research, InterJournal, Complex Systems 1695. 2006. Available from:
40 <https://igraph.org>.
41
42
43 94. Epskamp S, Constantini, G., Haslbeck, J. & Isvoranu, A. Package:
44 'qgraph' 2021. Available from: [https://cran.r-](https://cran.r-project.org/web/packages/qgraph/qgraph.pdf)
45 [project.org/web/packages/qgraph/qgraph.pdf](https://cran.r-project.org/web/packages/qgraph/qgraph.pdf).
46
47
48 95. Epskamp S, Cramer, A., Waldorp, L., Schmittmann, V. & Borsboom, D.,
49 . qgraph: Network Visualizations of Relationships in Psychometric Data:
50 Journal of Statistical Software, 48(4), 1-18. ; 2012. Available from:
51 <http://www.jstatsoft.org/v48/i04/>.
52
53
54
55
56
57
58
59
60

- 1
2
3
4 96. R Core Team. R: A language and environment for statistical computing
5 Vienna, Austria: R Foundation for Statistical Computing; 2021. Available
6 from: <https://www.R-project.org/>.
7
8
9 97. van Borkulo & Epskamp SwcfR, A. Package 'IsingFit' 2016. Available
10 from: <https://cran.r-project.org/web/packages/IsingFit/IsingFit.pdf>.
11
12
13 98. Wickham H. ggplot2: Elegant Graphics for Data Analysis. New York:
14 Springer-Verlag New York; 2016.
15
16
17 99. Epskamp S, van Borkulo CD, van der Veen DC, et al. Personalized
18 Network Modeling in Psychopathology: The Importance of
19 Contemporaneous and Temporal Connections. *Clinical Psychological*
20 *Science*. 2018;6(3):416-27.
21
22
23
24 100. van Borkulo CD, Borsboom D, Epskamp S, et al. A new method for
25 constructing networks from binary data. *Sci Rep*. 2014;4(1):5918-
26
27
28 101. Fruchterman TMJ, Reingold EM. Graph drawing by force-directed
29 placement. *Software: Practice and Experience*. 1991;21(11):1129-64.
30
31
32 [dataset] 102. Rex M. Data from: Final Major Network. The Open Science
33 Framework Repository, October 19, 2021. Available from:
34 https://osf.io/3dhtf/?view_only=084563d6b38a4f5aa32f6d76c50c0a34.
35
36
37 [dataset] 103. Rex M. Data from: Final deficiencies network. The Open
38 Science Framework Repository, October 20, 2021. Available from:
39 https://osf.io/3dhtf/?view_only=084563d6b38a4f5aa32f6d76c50c0a34.
40
41
42
43 [dataset] 104. Rex M. Data from: Final Contributing factors network. The Open
44 Science Framework Repository, October 14, 2021. Available from:
45 https://osf.io/3dhtf/?view_only=084563d6b38a4f5aa32f6d76c50c0a34.
46
47
48
49 [dataset] 105. Rex M. R script used in the manuscript Coexisting service
50 related factors preceding suicide: A network analysis. The Open
51 Science Framework Repository, October 21, 2021. Available from:
52 https://osf.io/3dhtf/?view_only=084563d6b38a4f5aa32f6d76c50c0a34.
53
54
55
56 106. Epskamp S. Package: 'bootnet' 2021 updated 2021-10-25. Available
57 from: <https://cran.r-project.org/web/packages/bootnet/bootnet.pdf>.
58
59
60

1
2
3
4 107. Fried EI, Robinaugh DJ. Systems all the way down: embracing
5 complexity in mental health research. *BMC Med.* 2020;18(1):205-
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

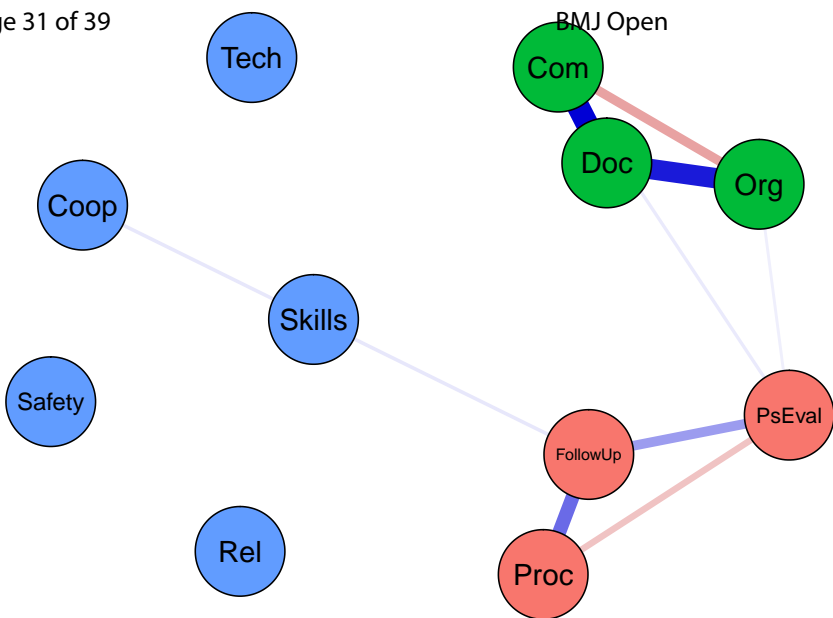
23 Figure 1. Major Network: significant differences ($\alpha = 0.05$) of edges.
24
25
26

27 Figure 2. Major network: standardized centrality index and significant differences ($\alpha = 0.05$) of
28 node strength.
29
30
31
32

33 Figure 3. Deficiencies network: significant differences ($\alpha = 0.05$) of edges.
34
35
36
37

38 Figure 4. Deficiencies network: standardized centrality index and significant differences ($\alpha = 0.05$)
39 of node strength.
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

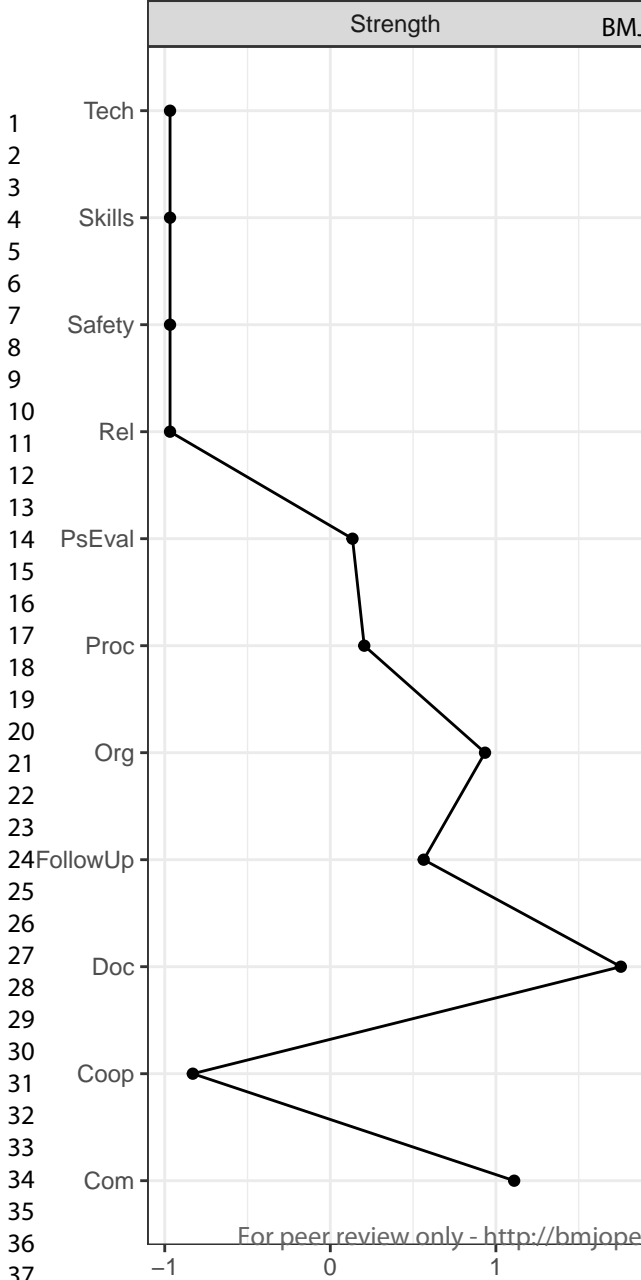
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38



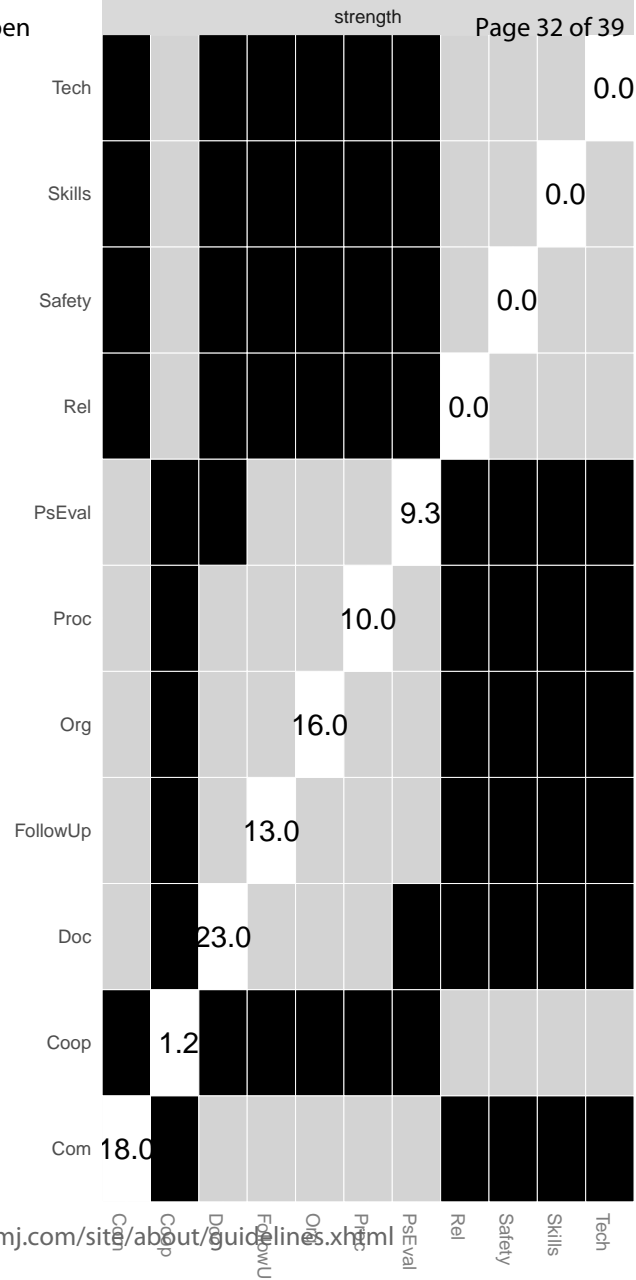
- Community 1
- Community 2
- Disconnected nodes

edge

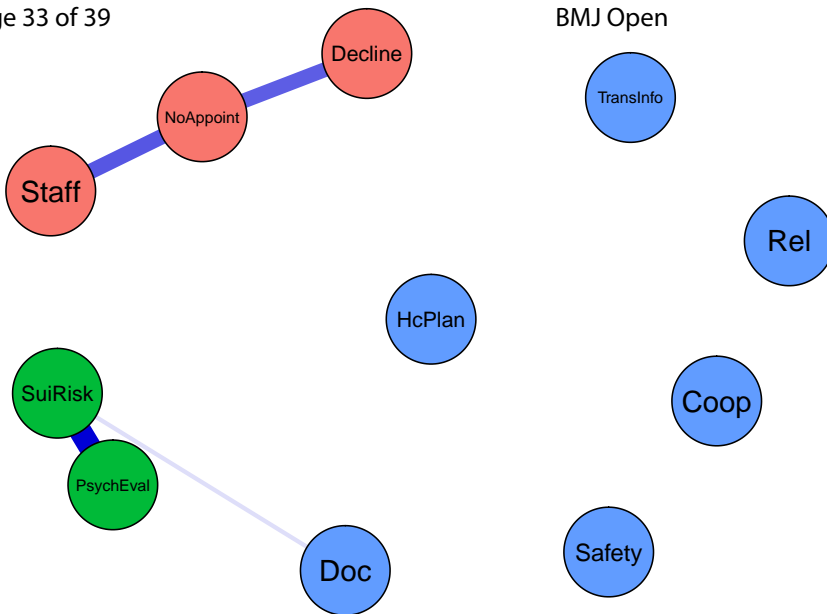
Doc—Com									
Doc—Org									
FollowUp—Proc									
PsEval—FollowUp									
Coop—FollowUp									
PsEval—Com									
PsEval—Org									
PsEval—Proc									
Org—Com									
	Org—Com	PsEval—Proc	PsEval—Org	PsEval—Com	Coop—FollowUp	PsEval—FollowUp	FollowUp—Proc	Doc—Org	Doc—Com



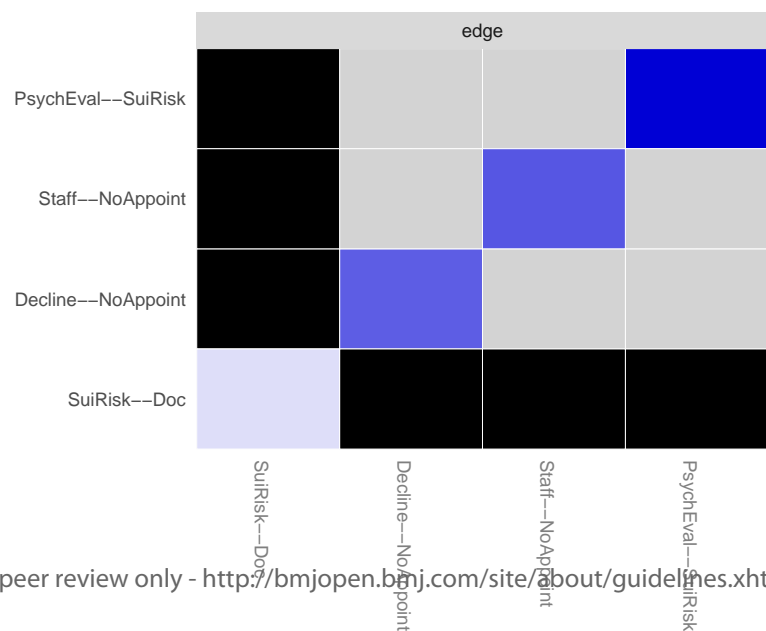
For peer review only - <http://bmjopen.bmj.com/site/about/guidelines.xhtml>

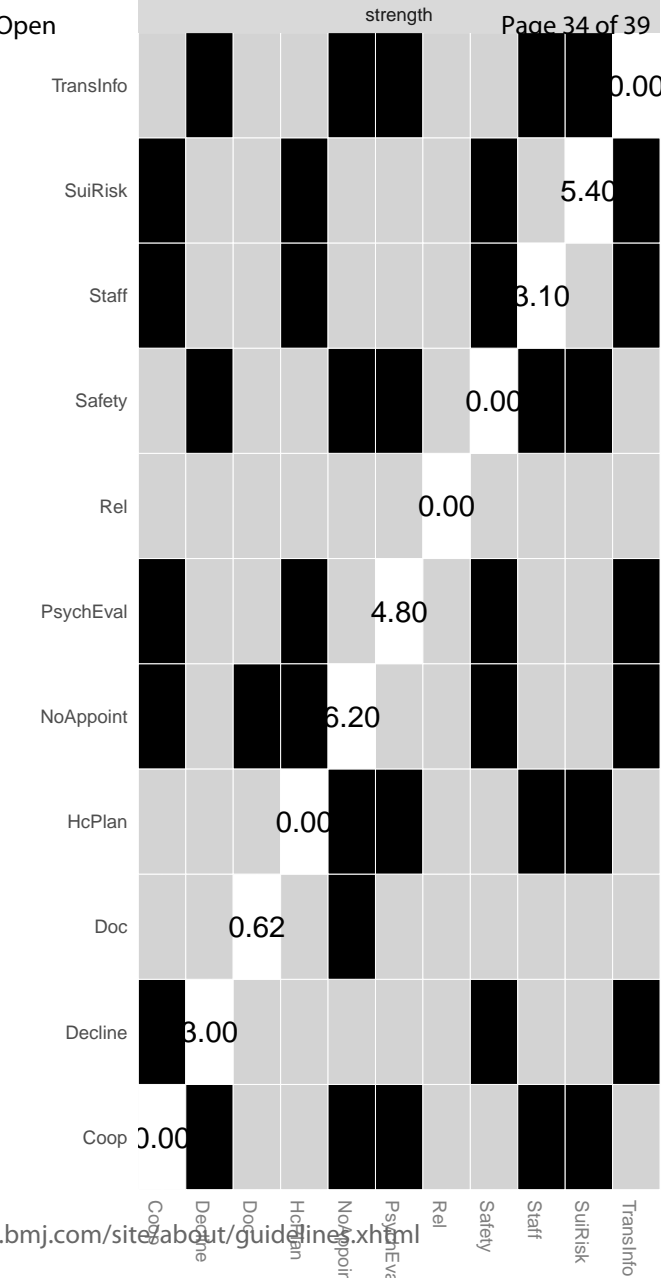
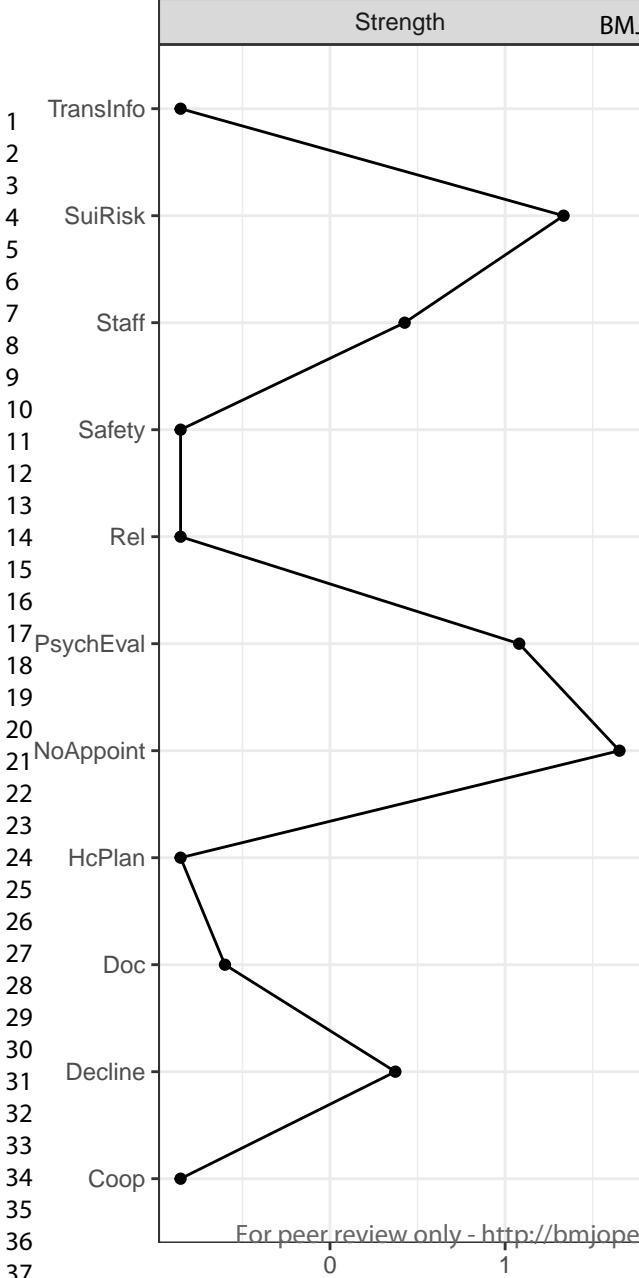


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38



- Community 1
- Community 2
- Disconnected nodes





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

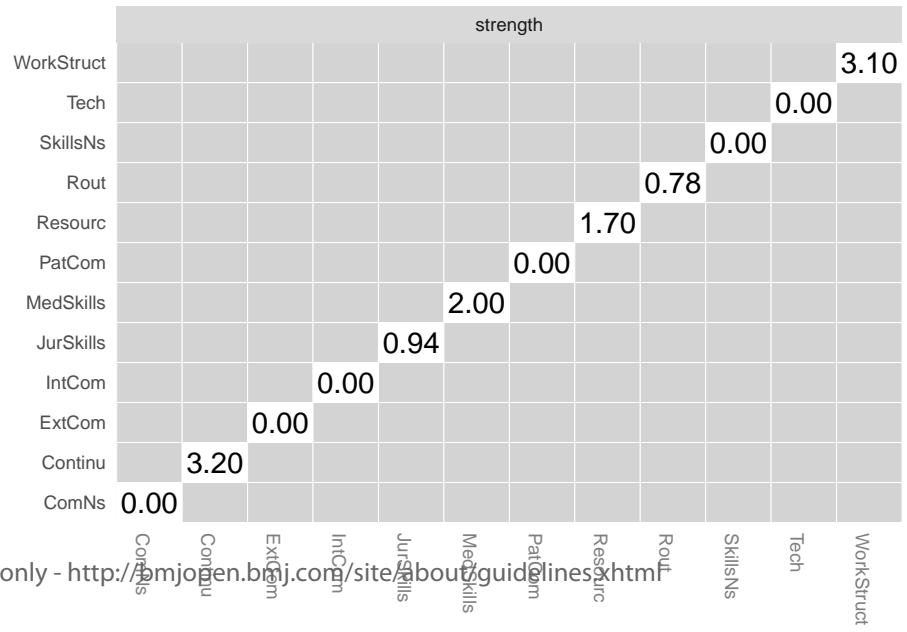
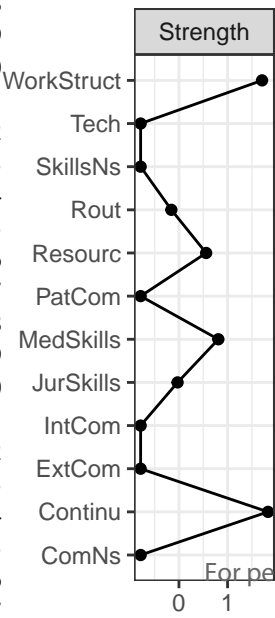
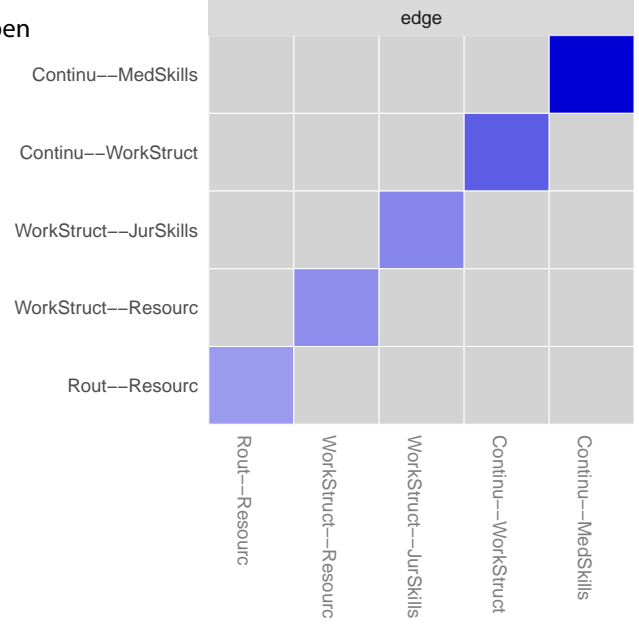
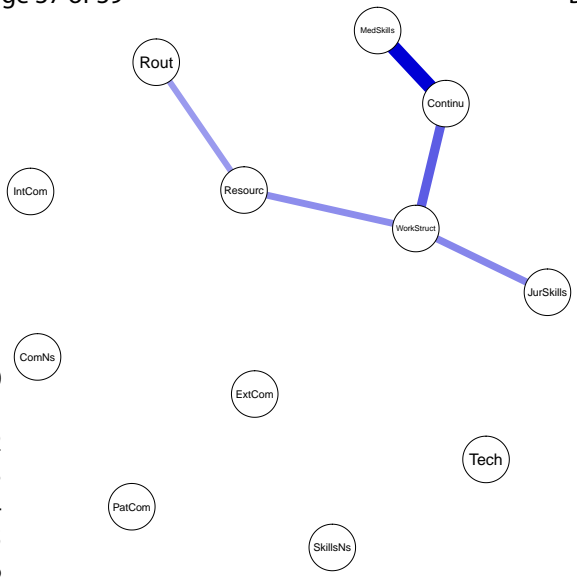
1			
2	Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted
3			estimates and their precision (eg, 95% confidence interval). Make clear
4			which confounders were adjusted for and why they were included
5			7-8, 11
6			(b) Report category boundaries when continuous variables were
7			categorized
8			N/A
9			(c) If relevant, consider translating estimates of relative risk into absolute
10			risk for a meaningful time period
11	Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions,
12			and sensitivity analyses
13			N/A
14	Discussion		
15	Key results	18	Summarise key results with reference to study objectives
16	Limitations	19	Discuss limitations of the study, taking into account sources of potential
17			bias or imprecision. Discuss both direction and magnitude of any
18			potential bias
19			15-16
20	Interpretation	20	Give a cautious overall interpretation of results considering objectives,
21			limitations, multiplicity of analyses, results from similar studies, and
22			other relevant evidence
23			13-15
24	Generalisability	21	Discuss the generalisability (external validity) of the study results
25			13-15
26	Other information		
27	Funding	22	Give the source of funding and the role of the funders for the present
28			study and, if applicable, for the original study on which the present
29			article is based
30			16

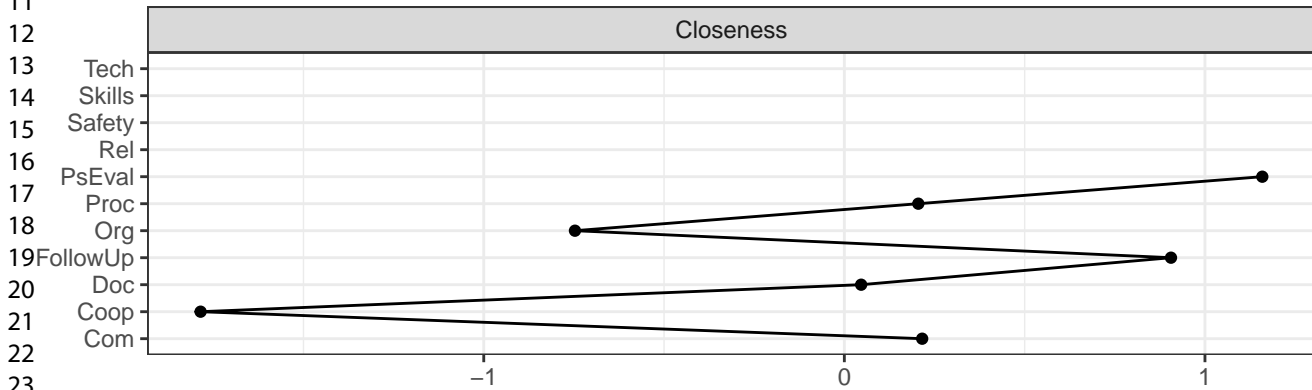
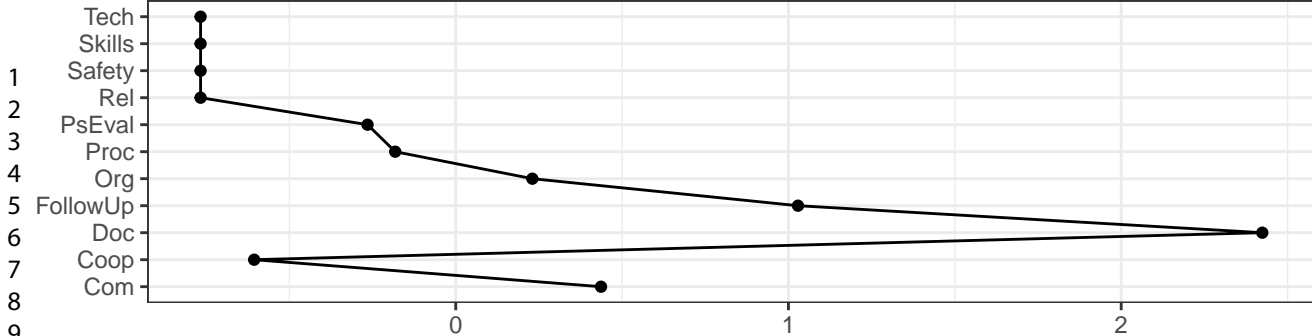
*Give information separately for exposed and unexposed groups.

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.

BMJ Open

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38





BMJ Open

