How teams adapt to exogenous shocks: Experimental evidence with node knockouts of central members

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Researchers have found that although external attacks, exogenous shocks, and node knockouts can disrupt networked systems, they rarely lead to the system's collapse. Although these processes are widely understood, most studies of how exogenous shocks affect networks rely on simulated or observational data. Thus, little is known about how groups of real individuals respond to external attacks. In this article, we employ an experimental design in which exogenous shocks, in the form of the unexpected removal of a teammate, are imposed on small teams of people who know each other. This allows us to causally identify the removed individual's contribution to the team structure, the effect that an individual had on those they were connected, and the effect of the node knockout on the team. At the team level, we find that node knockouts decrease overall internal team communication. At the individual level, we find that node knockouts cause the remaining influential players to become more influential, while the remaining peripheral players become more isolated within their team. In addition, we also find that node knockouts may have a nominal influence on team performance. These findings shed light on how teams respond and adapt to node knockouts.

1 Supporting Information

The supporting information contains:

1. Description of the data.
2. Model fit.
3. Alternative team level dependent variables.
4. Alternative individual level dependent variables.
5. Alternative team level model specifications.
6. Alternative individual level model specifications.
7. Alternative team level controls.
8. Alternative individual level controls.
9. Sensitivity analysis.

2 Description of the data

2.1 Network attributes

In the experiment, we analyze changes in the communication frequency network constrained by an overall communication network based on teams' preexisting social networks. The treated experiment teams have three networks, the: (a) pre-knockout communication network, (b) post-knockout communication network, and (c) the communication networks. The control teams have two networks, the: (a) the communication network and (b) the communication frequency network. The communication frequency network is a directed and weighted network for the number of messages sent per round by each team. Table 1 displays descriptive statistics of the networks by round for the network density, diameter, transitivity, and messages sent. After the knockout rounds, the treated networks see modest increases in network density, diameter, and transitivity, however, those networks have fewer nodes. Table 2 displays descriptive statistics on the communication network. These networks are undirected and reflections of the teammates preexisting social networks. The

Table 1: Description of the communication frequency network data by round. The communication frequency networks are weighted and directed from the messages. During the experiment, participants could only communicate over their communication network.

	Density		Diameter		Transitivity		Messages	
Round	Control	Treatment	Control	Treatment	Control	Treatment	Control	Treatment
1	0.39	0.37	5.58	6.15	0.50	0.43	37.89	36.67
2	0.48	0.47	5.84	5.36	0.52	0.55	50.21	46.24
3	0.51	0.48	5.26	5.88	0.57	0.54	53.74	50.24
4	0.52	0.52	5.63	5.64	0.55	0.57	57.53	57.36
5	0.54	0.52	5.42	5.73	0.57	0.57	59.53	56.76
6	0.55	0.61	5.32	5.45	0.57	0.64	64.58	50.18
7	0.52	0.59	5.84	5.15	0.55	0.63	62.63	48.70
8	0.54	0.59	5.47	5.09	0.58	0.62	62.16	48.27
9	0.54	0.57	6.05	5.18	0.56	0.61	65.26	47.30
10	0.52	0.55	5.79	5.48	0.55	0.61	62.42	47.33

Table 2: Description of the communication network data by round. In the control trials there is only one communication network, while the treatment trials have a pre- and post-knockout communication network. These networks are unweighted and undirected. The pre-knockout and control communication networks are determined at the start of the experiment by teammates selecting the top three teammates whose judgment they most respected. The post-knockout communication network allowed users to select a new chat partner if they had selected the knocked-out teammate.

	Density		Communication diameter		Transitivity		Degree centralization	
Time	Control	Treatment	Control	Treatment	Control	Treatment	Control	Treatment
Pre-knockout	0.63	0.64	2.21	2.03	0.61	0.62	0.27	0.28
Post-knockout	−−	0.70	−−	2.00	−−	0.67	−−	0.23

changes in the treated communication network density and transitivity are statistically significant for the pre- and post-knockout communication network (see Figure 1).

2.2 Communication network plot

In the experiment, the control trials trials have a single communication network based on their preexisting social network. Figure 2 is a visualization of the restricted communication networks of the experimental control teams. Table 3 displays the corresponding network attributes for the communication networks.

In the experiment, the treatment trials trials have a two communication networks, the pre- and post-knockout communication networks. The pre-knockout communication network is based

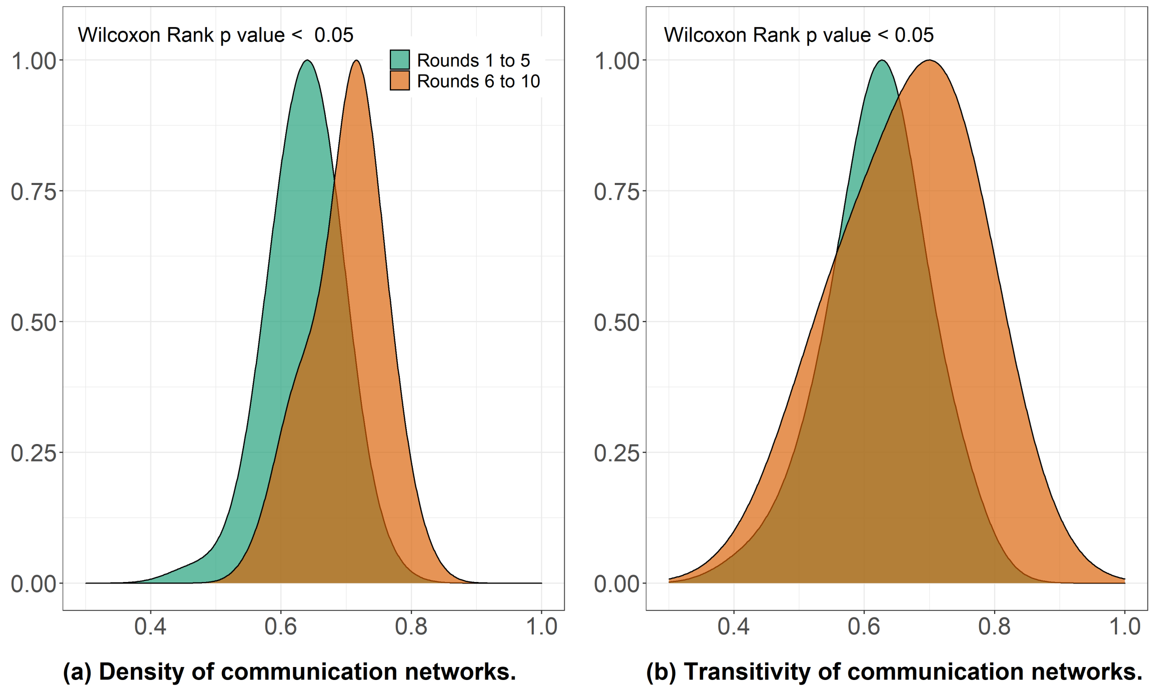


Figure 1: These plots illustrate changes in the communication network density, cell (a) density; and cell (b) transitivity for pre- and post-knockout teams. Using a paired Wilcoxon Rank test, we find pre- and post-knockout communication density and transitivity networks are statistically different at the 0.05 level.

on their preexisting social network and the post-knockout communication network is their adapted communication network after the knockout. Figure 3-6 is a visualization of the restricted communication networks of the experimental treatment teams. Each plot highlights the knocked-out experiment participant in the plotted data. Table 3 displays the corresponding network attributes for the communication networks.

2.3 Communication network frequency plots

We also collect data on the number of messages sent to create a communication frequency network. The messaging network is restricted to the preexisting communication network. We use the difference in the communication frequency network from the pre- and post-knockout networks to assess how participants adjusted to the node knockouts. Figure 7-32 display adjacency matrix heat maps of the communication frequency networks by round for each team.

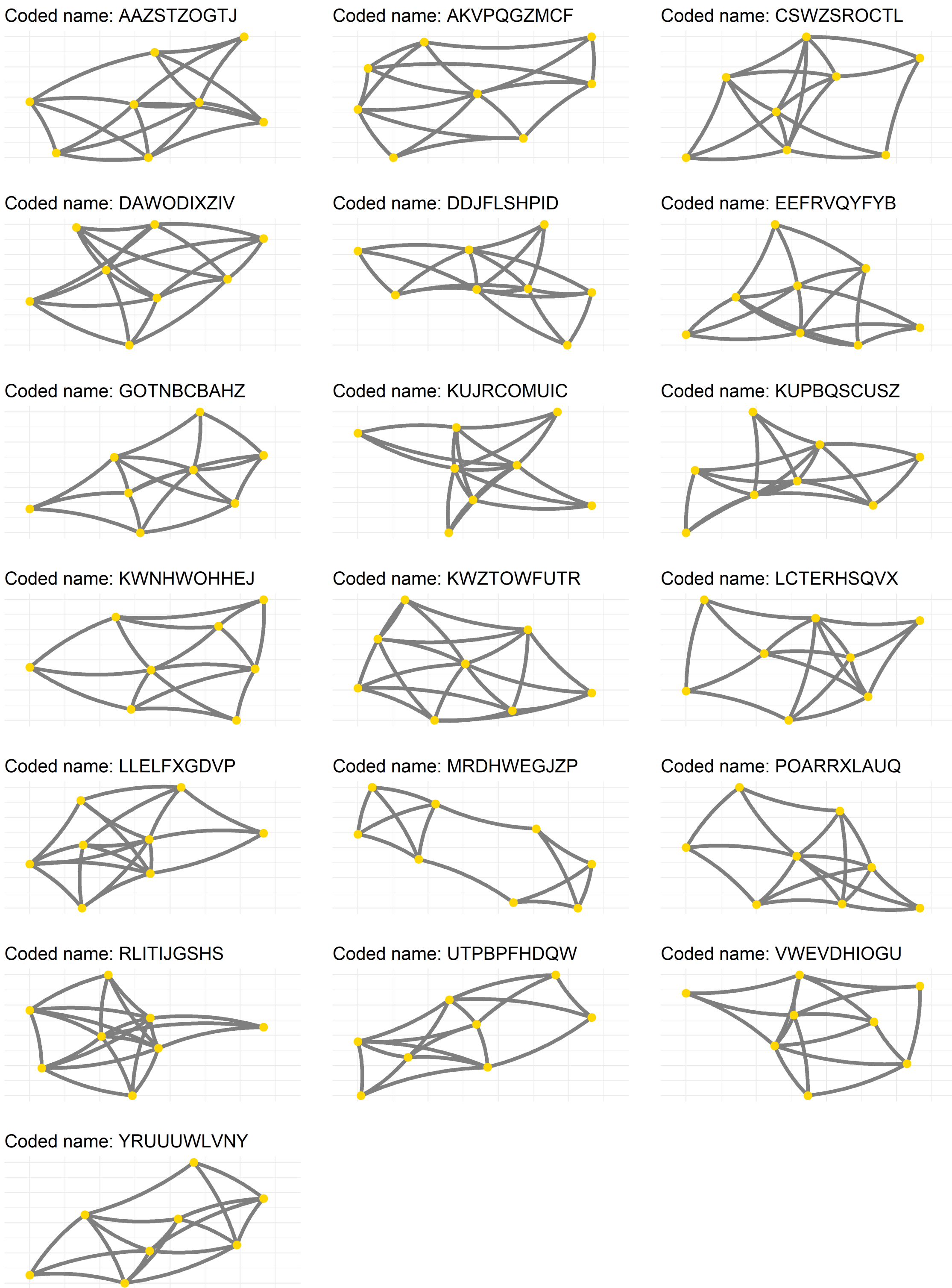


Figure 2: Communication networks of the control trails. The coded network names correspond to the descriptive statistics in Table 3.

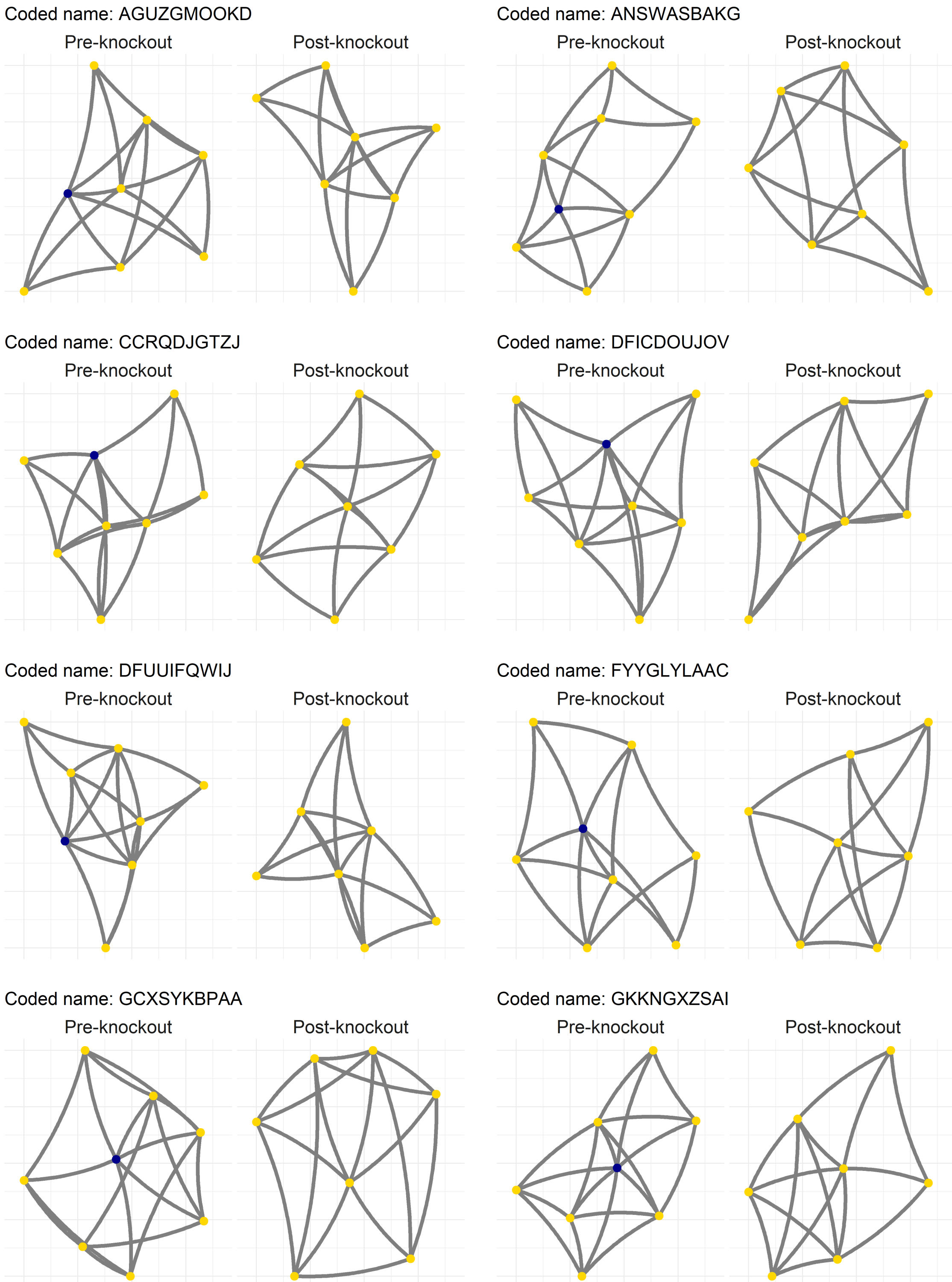


Figure 3: Communication networks of the pre- and post-knockout communication networks for experimental teams 1-8. The blue nodes in the pre-knockout communication network are the removed nodes. The coded network names correspond to the descriptive statistics in Table 3.

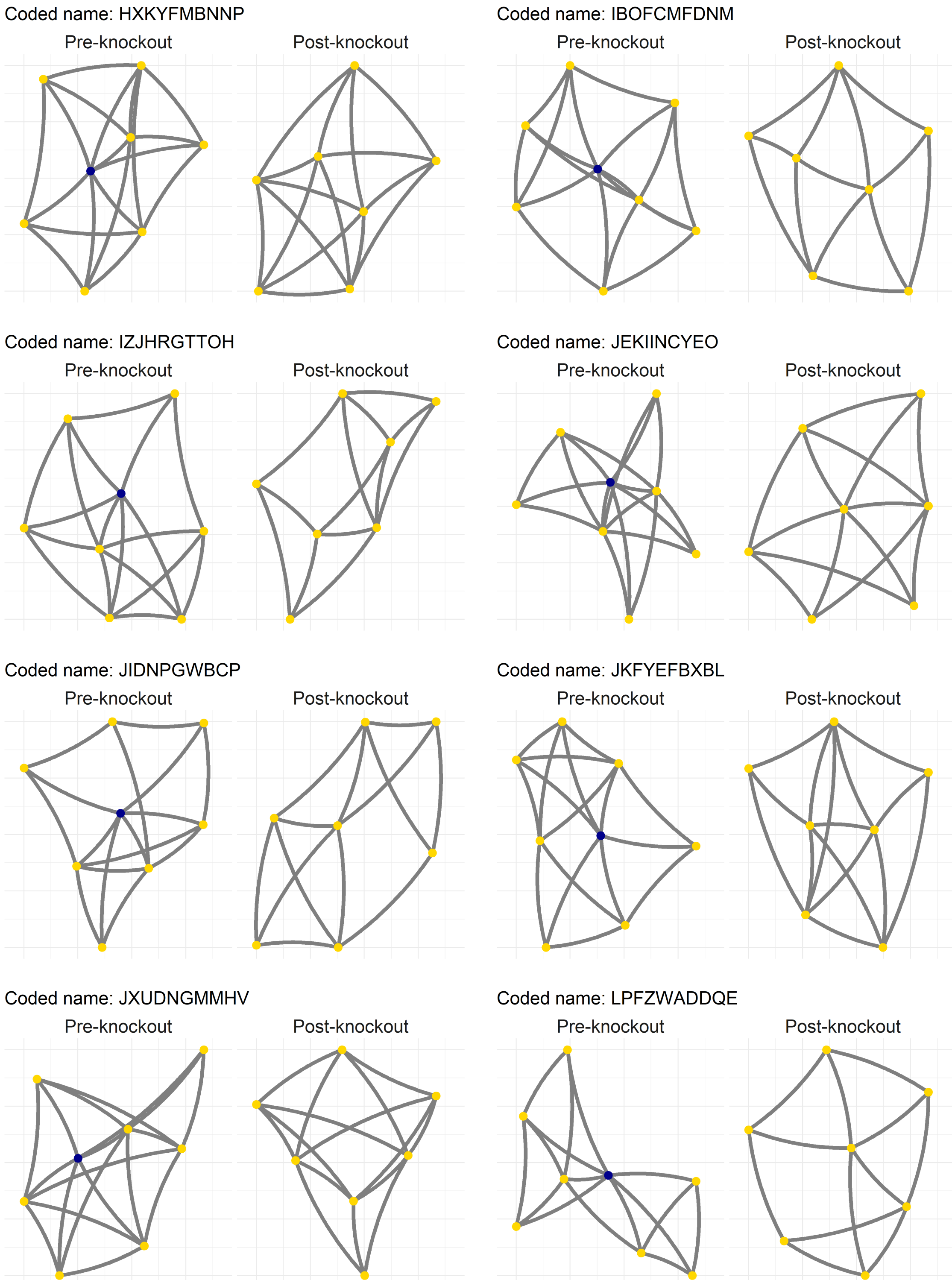


Figure 4: Communication networks of the pre- and post-knockout communication networks for experimental teams 9-16. The coded network names correspond to the descriptive statistics in Table 3.

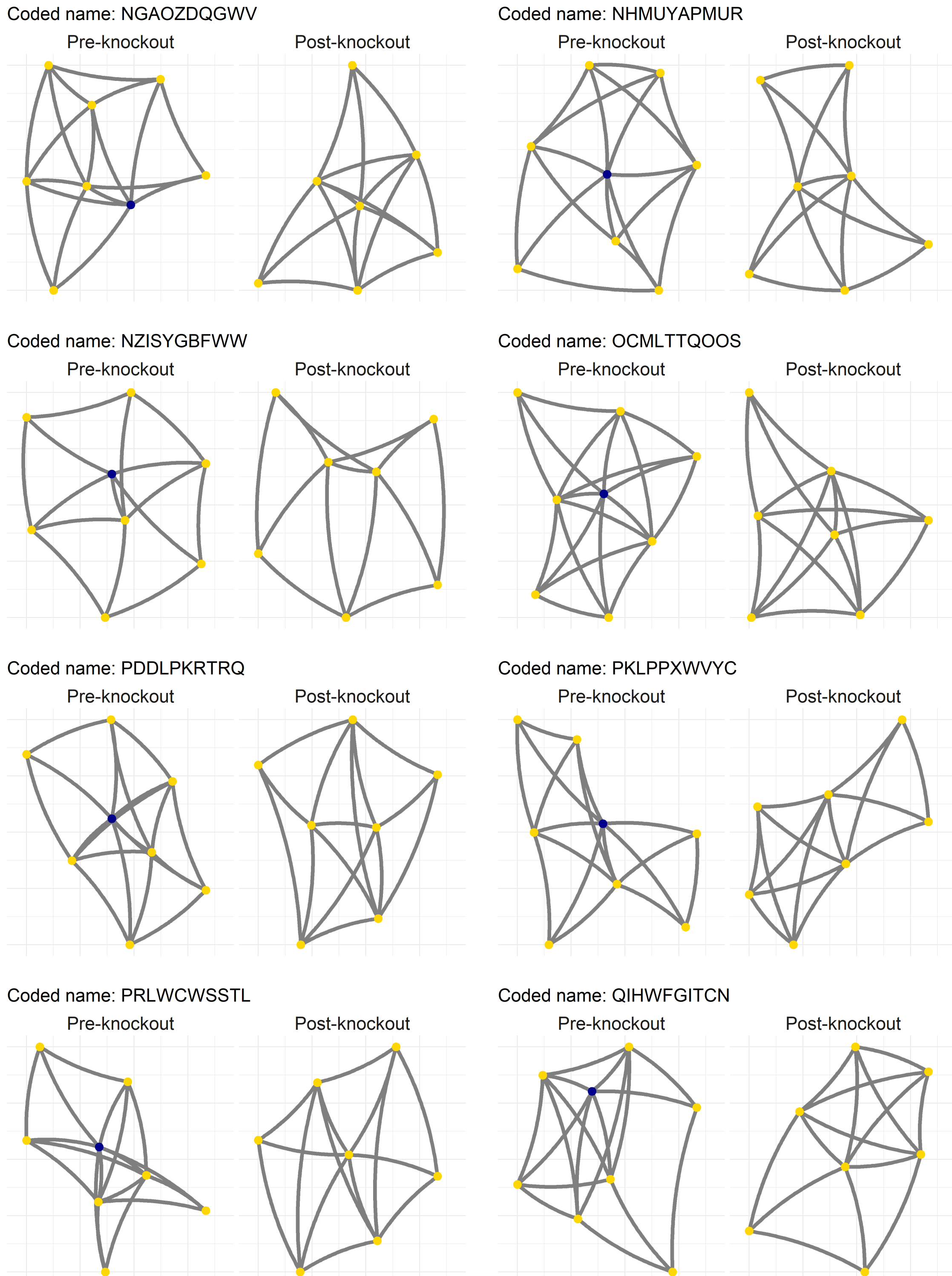


Figure 5: Communication networks of the pre- and post-knockout communication networks for experimental teams 17-24. The blue nodes in the pre-knockout communication network are the removed nodes. The coded network names correspond to the descriptive statistics in Table 3.

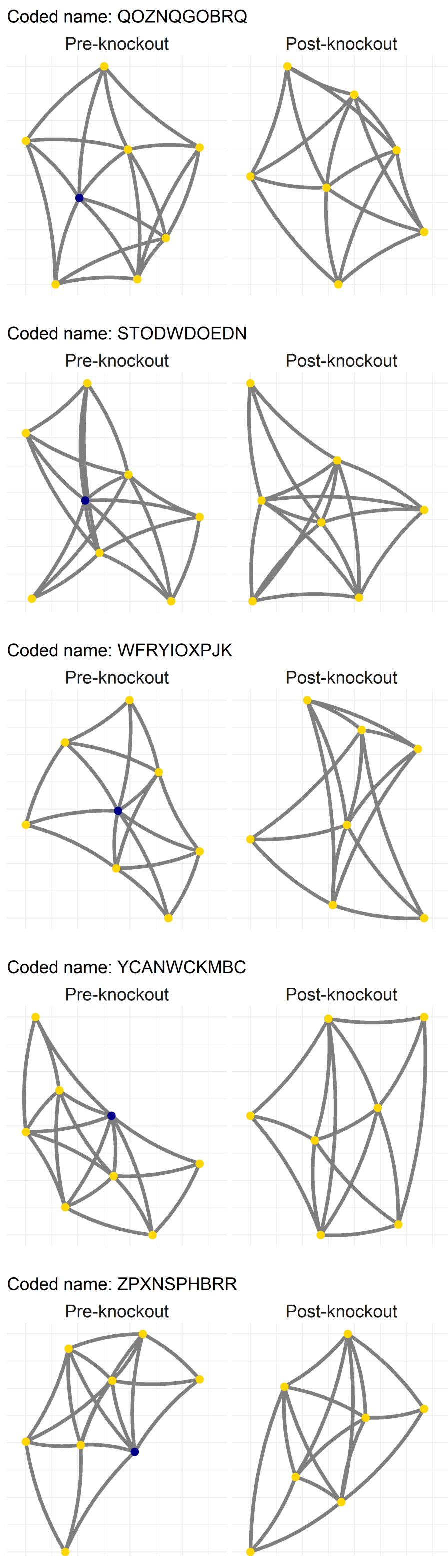


Figure 6: Communication networks of the pre- and post-knockout communication networks for experimental teams 25-33. The blue nodes in the pre-knockout communication network are the removed nodes. The coded network names correspond to the descriptive statistics in Table 3.

Table 3: Descriptive data for each communication network. The coded names correspond to Figures 2-6

	Pre-knockout and control comm. networks				Pre-knockout comm. network			
Coded name	Density	Diameter	Transitivity	Deg. central.	Density	Diameter	Transitivity	Deg. central.
AAZSTZOGTJ	0.64	2	0.58	0.21	−−	−−	−−	−−
AGUZGMOOKD	0.61	2	0.49	0.25	0.71	2	0.71	0.29
AKVPQGZMCF	0.61	2	0.59	0.39	−−	−−	−−	−−
ANSWASBAKG	0.57	3	0.59	0.14	0.67	2	0.56	0.17
CCRQDJGTZJ	0.64	2	0.69	0.21	0.71	2	0.74	0.29
CSWZSROCTL	0.64	3	0.65	0.21	−−	−−	−−	−−
DAWODIXZIV	0.68	2	0.57	0.18	−−	−−	−−	−−
DDJFLSHPID	0.64	2	0.67	0.36	−−	−−	−−	−−
DFICDOUJOV	0.68	2	0.72	0.32	0.71	2	0.74	0.29
DFUUIFQWIJ	0.68	2	0.72	0.18	0.71	2	0.71	0.29
EEFRVQYFYB	0.61	2	0.54	0.25	−−	−−	−−	−−
FYYGLYLAAC	0.57	2	0.46	0.29	0.67	2	0.55	0.17
GCXSYKBPAA	0.64	2	0.55	0.21	0.76	2	0.71	0.24
GKKNGXZSAI	0.68	2	0.70	0.32	0.71	2	0.74	0.29
GOTNBCBAHZ	0.61	2	0.51	0.25	−−	−−	−−	−−
HXKYFMBNNP	0.68	2	0.64	0.32	0.76	2	0.67	0.07
IBOFCMFDNM	0.64	2	0.63	0.36	0.62	2	0.57	0.21
IZJHRGTTOH	0.64	2	0.63	0.21	0.62	2	0.57	0.21
JEKIINCYEO	0.64	2	0.64	0.36	0.67	2	0.59	0.33
JIDNPGWBCP	0.57	2	0.51	0.29	0.62	2	0.57	0.21
JKFYEFBXBL	0.61	2	0.56	0.25	0.71	2	0.69	0.12
JXUDNGMMHV	0.68	2	0.60	0.18	0.71	2	0.59	0.12
KUJRCOMUIC	0.64	2	0.65	0.36	−−	−−	−−	−−
KUPBQSCUSZ	0.64	2	0.67	0.36	−−	−−	−−	−−
KWNHWOHHEJ	0.57	2	0.58	0.29	−−	−−	−−	−−
KWZTOWFUTR	0.68	2	0.64	0.32	−−	−−	−−	−−
LCTERHSQVX	0.61	3	0.60	0.25	−−	−−	−−	−−
LLELFXGDVP	0.68	2	0.66	0.32	−−	−−	−−	−−
LPFZWADDQE	0.57	2	0.65	0.43	0.57	2	0.48	0.26
MRDHWEGJZP	0.46	3	0.60	0.11	−−	−−	−−	−−
NGAOZDQGWV	0.64	2	0.62	0.21	0.76	2	0.77	0.24
NHMUYAPMUR	0.64	2	0.62	0.36	0.67	2	0.69	0.33
NZISYGBFWW	0.54	2	0.41	0.18	0.62	2	0.55	0.21
OCMLTTQOOS	0.71	2	0.75	0.29	0.76	2	0.70	0.24
PDDLPKRTRQ	0.68	2	0.66	0.32	0.71	2	0.69	0.12
PKLPPXWVYC	0.61	2	0.66	0.39	0.71	2	0.78	0.29
POARRXLAUQ	0.61	2	0.63	0.39	−−	−−	−−	−−
PRLWCWSSTL	0.64	2	0.63	0.36	0.71	2	0.74	0.29
QIHWFGITCN	0.64	2	0.58	0.21	0.71	2	0.74	0.29
QOZNQGOBRQ	0.68	2	0.65	0.18	0.76	2	0.71	0.24
QSNHXJVFHV	0.61	2	0.63	0.39	0.62	2	0.49	0.21
RLITIJGSHS	0.75	2	0.77	0.25	−−	−−	−−	−−
STODWDOEDN	0.68	2	0.62	0.32	0.81	2	0.81	0.19
TUKQFYFPZK	0.71	2	0.74	0.29	0.71	2	0.74	0.29
UTPBPFHDQW	0.61	3	0.61	0.11	−−	−−	−−	−−
VWEVDHIOGU	0.61	2	0.54	0.25	−−	−−	−−	−−
WFRYIOXPJK	0.61	2	0.63	0.39	0.71	2	0.62	0.29
XSBZRWRZET	0.61	2	0.54	0.25	0.67	2	0.60	0.33
YCANWCKMBC	0.68	2	0.73	0.32	0.71	2	0.69	0.12
YRUUUWLVNY	0.64	2	0.63	0.21	−−	−−	−−	−−
YULXLWMDMW	0.64	2	0.64	0.36	0.71	2	0.71	0.29
ZPXNSPHBRR	0.68	2	0.70	0.18	0.76	2	0.79	0.24

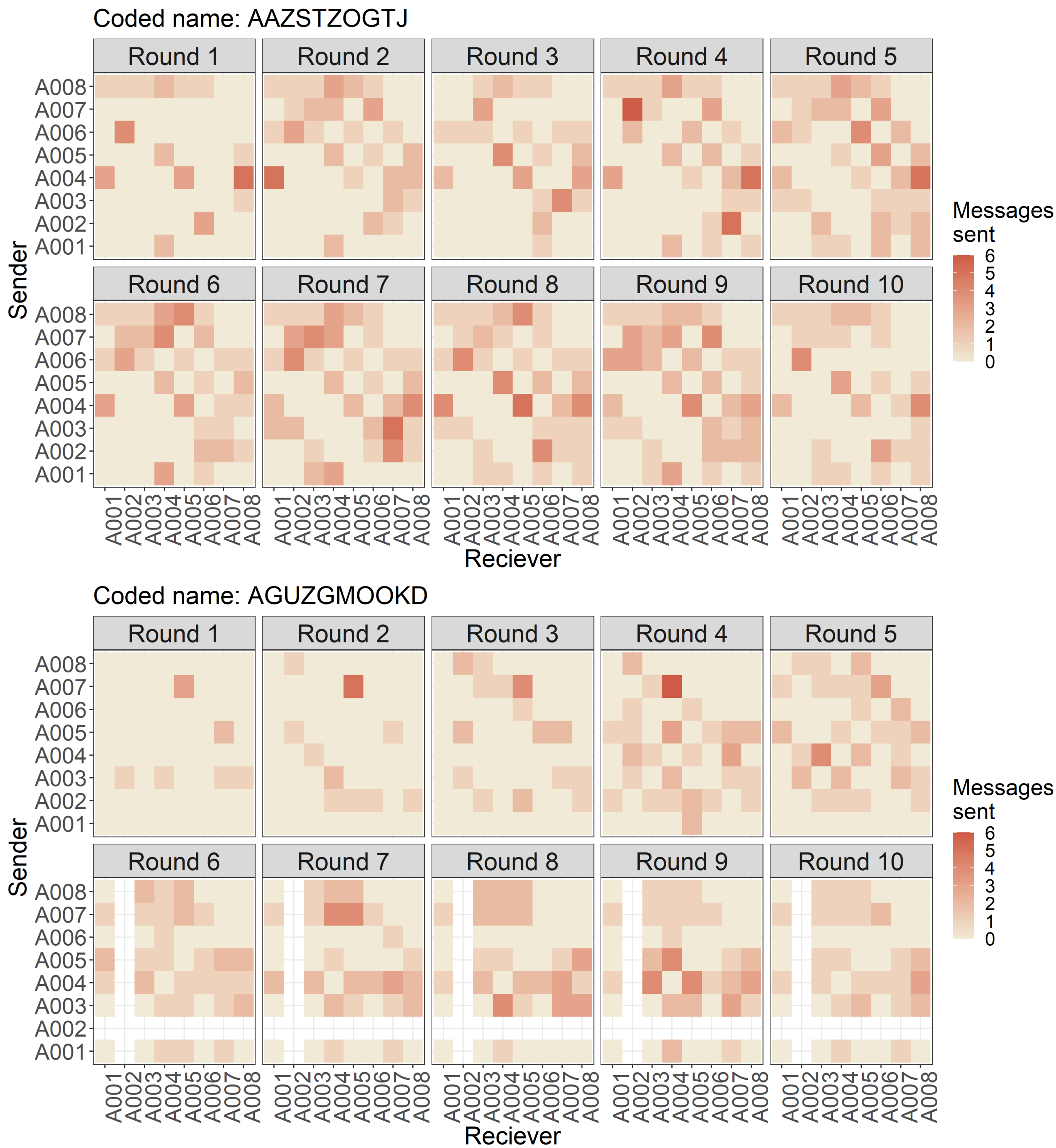


Figure 7: Communication frequency networks for teams 1-2.

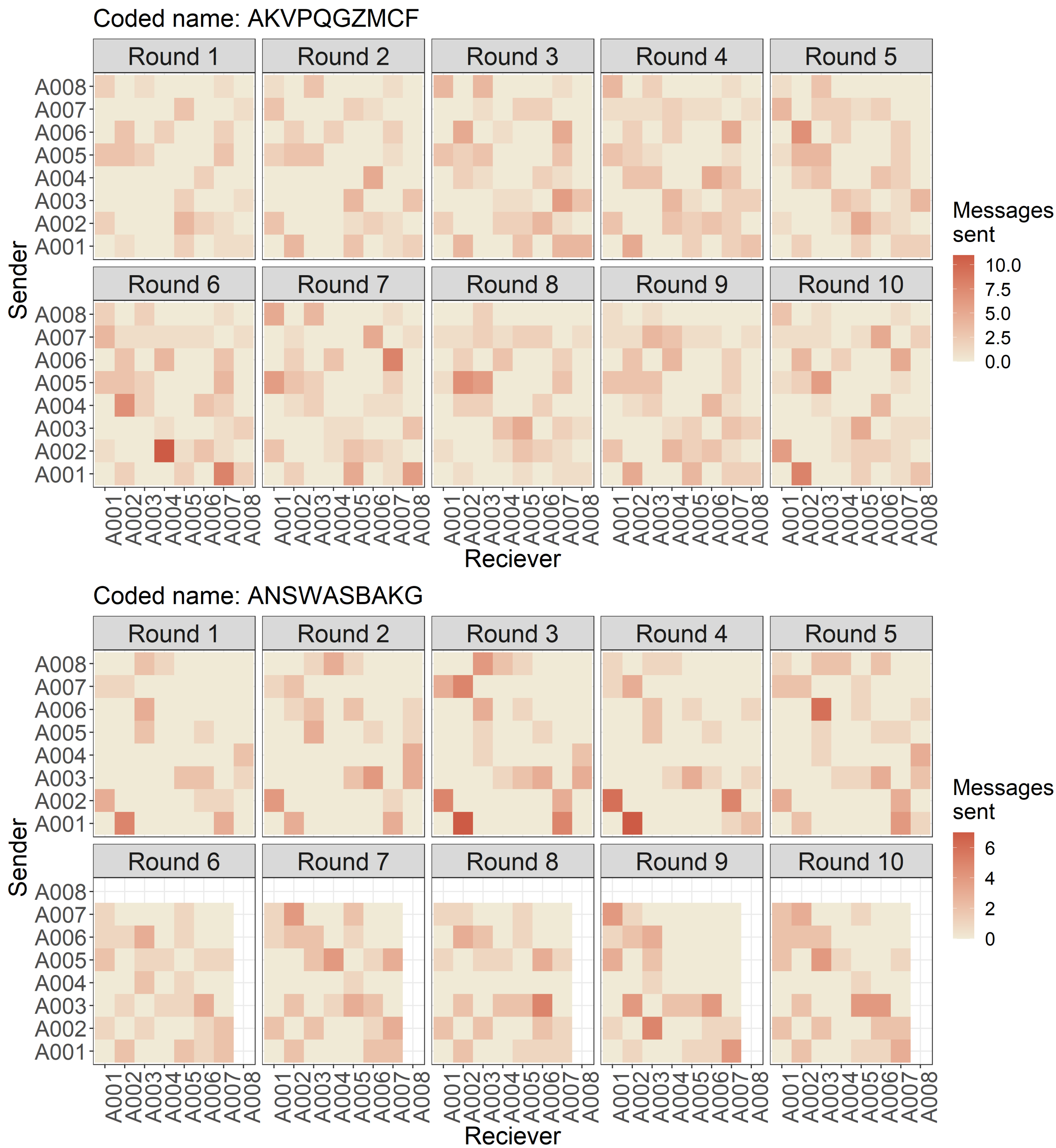


Figure 8: Communication frequency networks for teams 3-4.

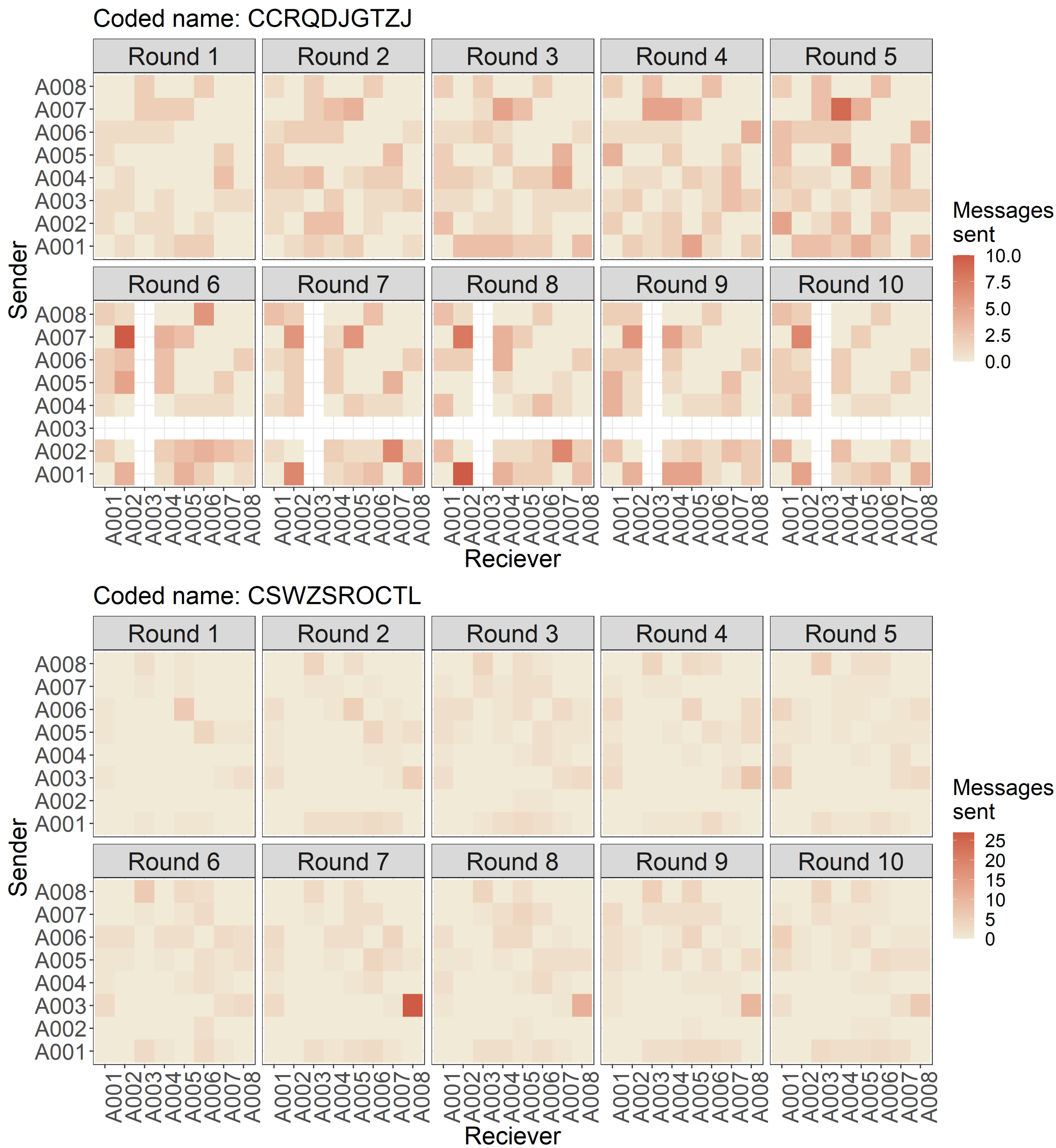


Figure 9: Communication frequency networks for teams 5-6.

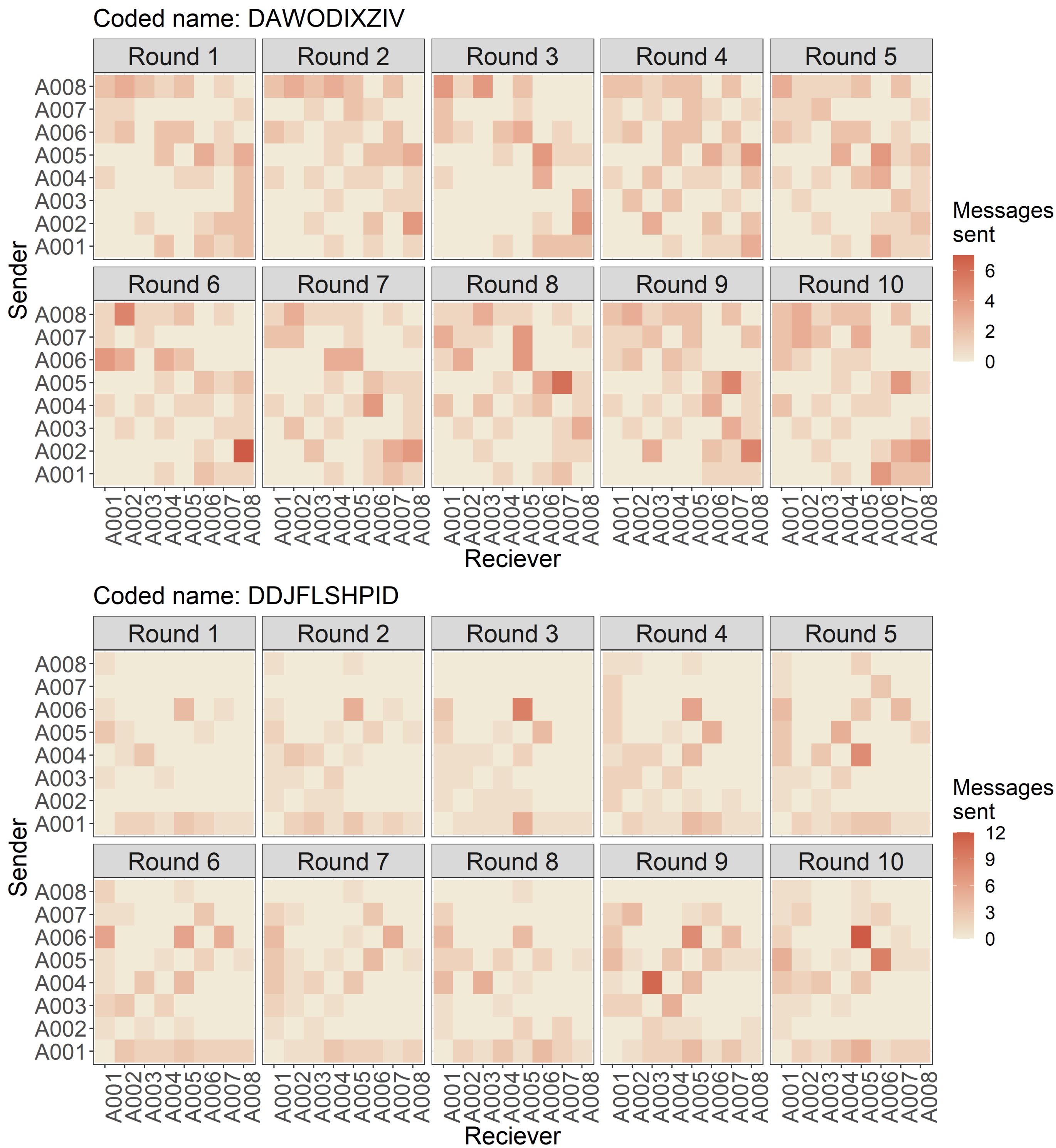


Figure 10: Communication frequency networks for teams 7-8.

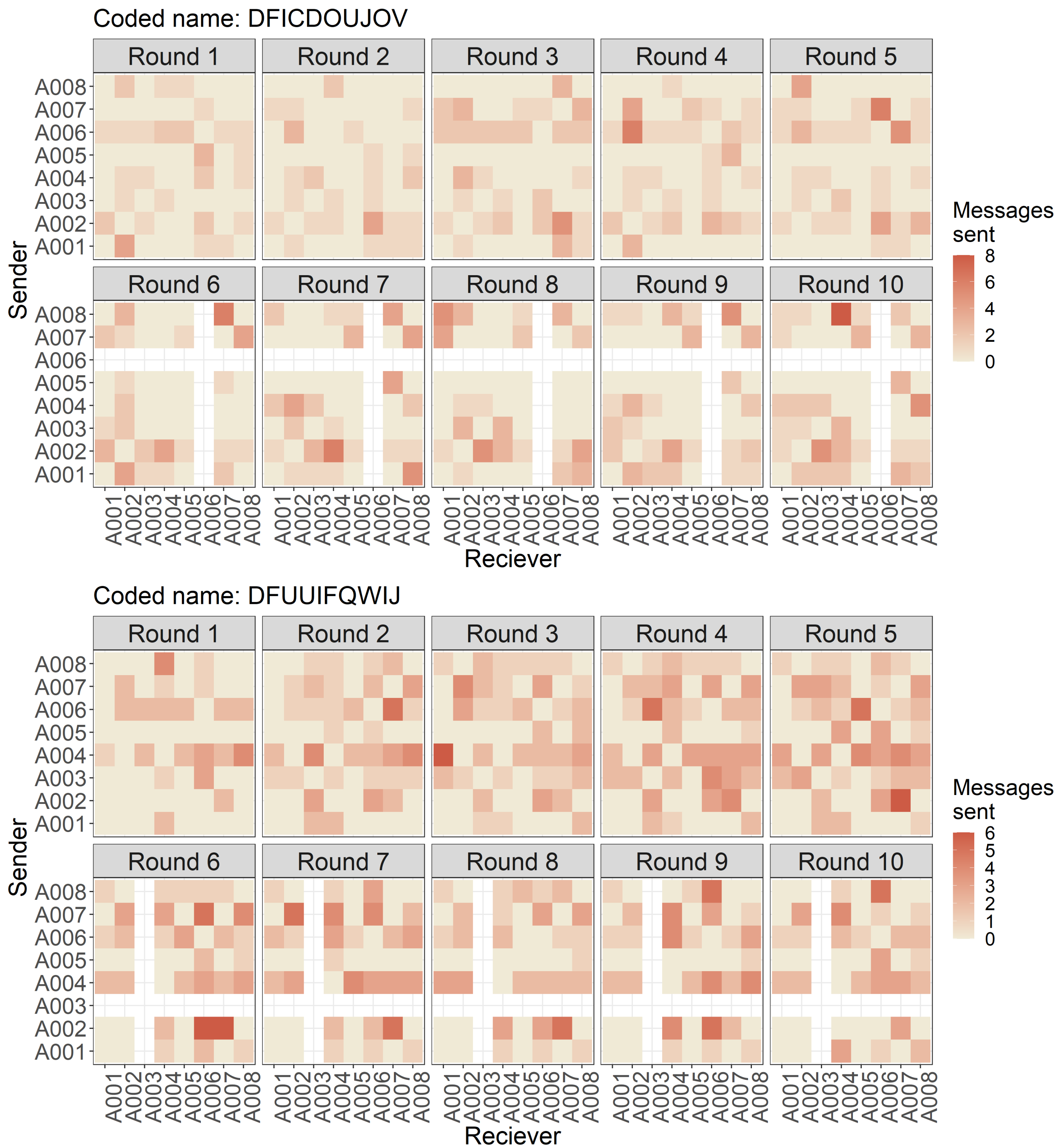


Figure 11: Communication frequency networks for teams 9-10.

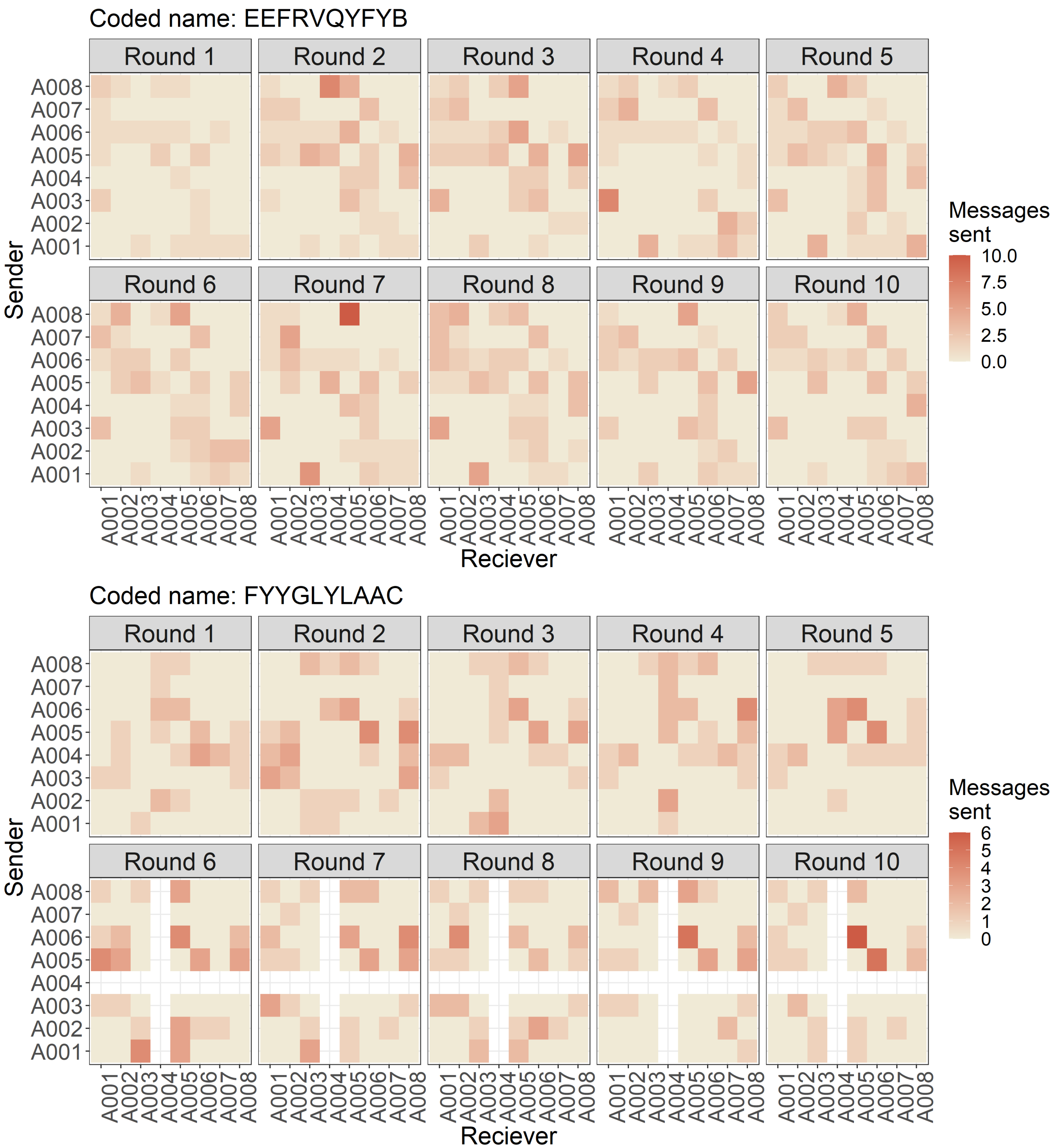


Figure 12: Communication frequency networks for teams 11-12.

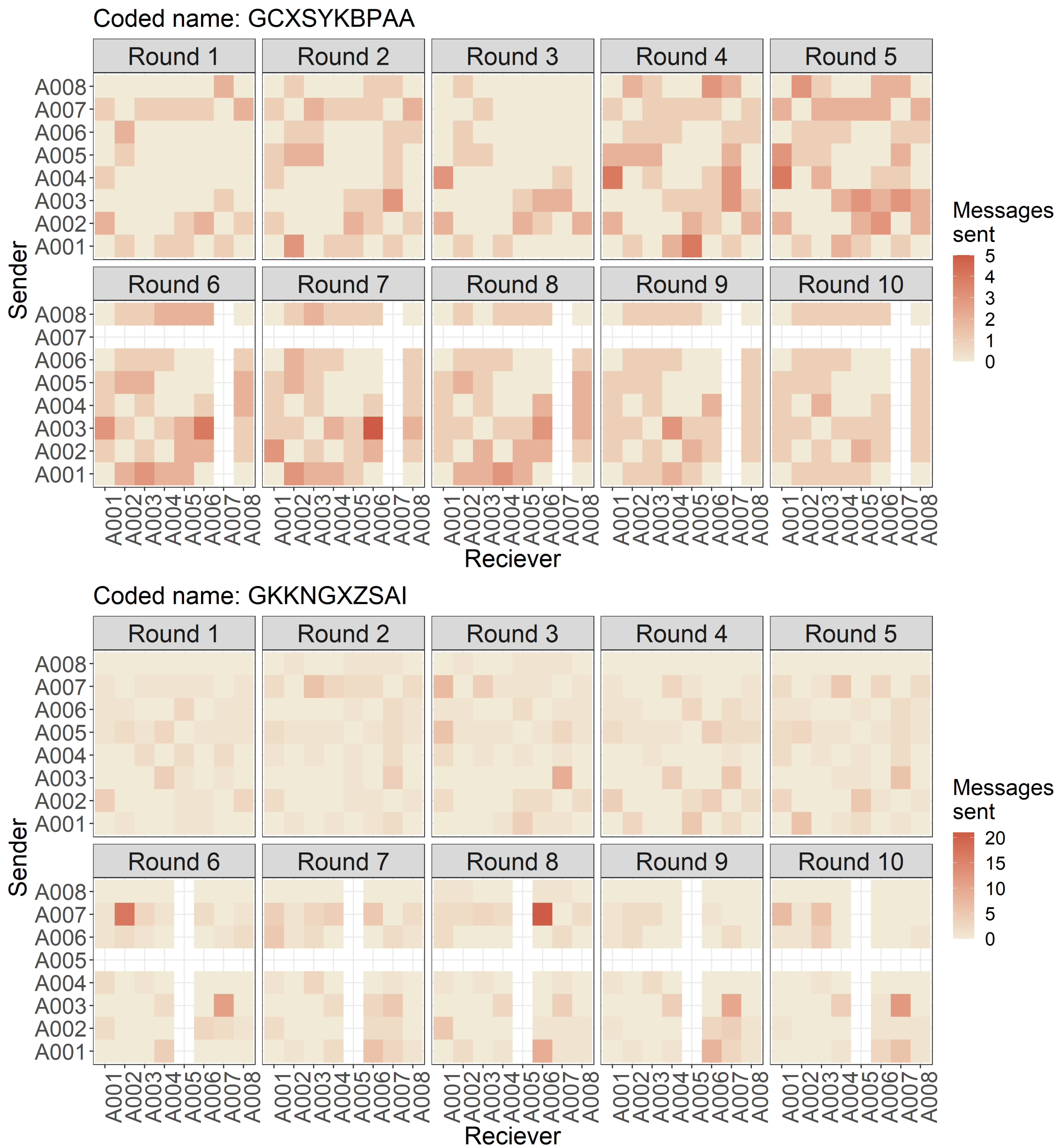


Figure 13: Communication frequency networks for teams 13-14.

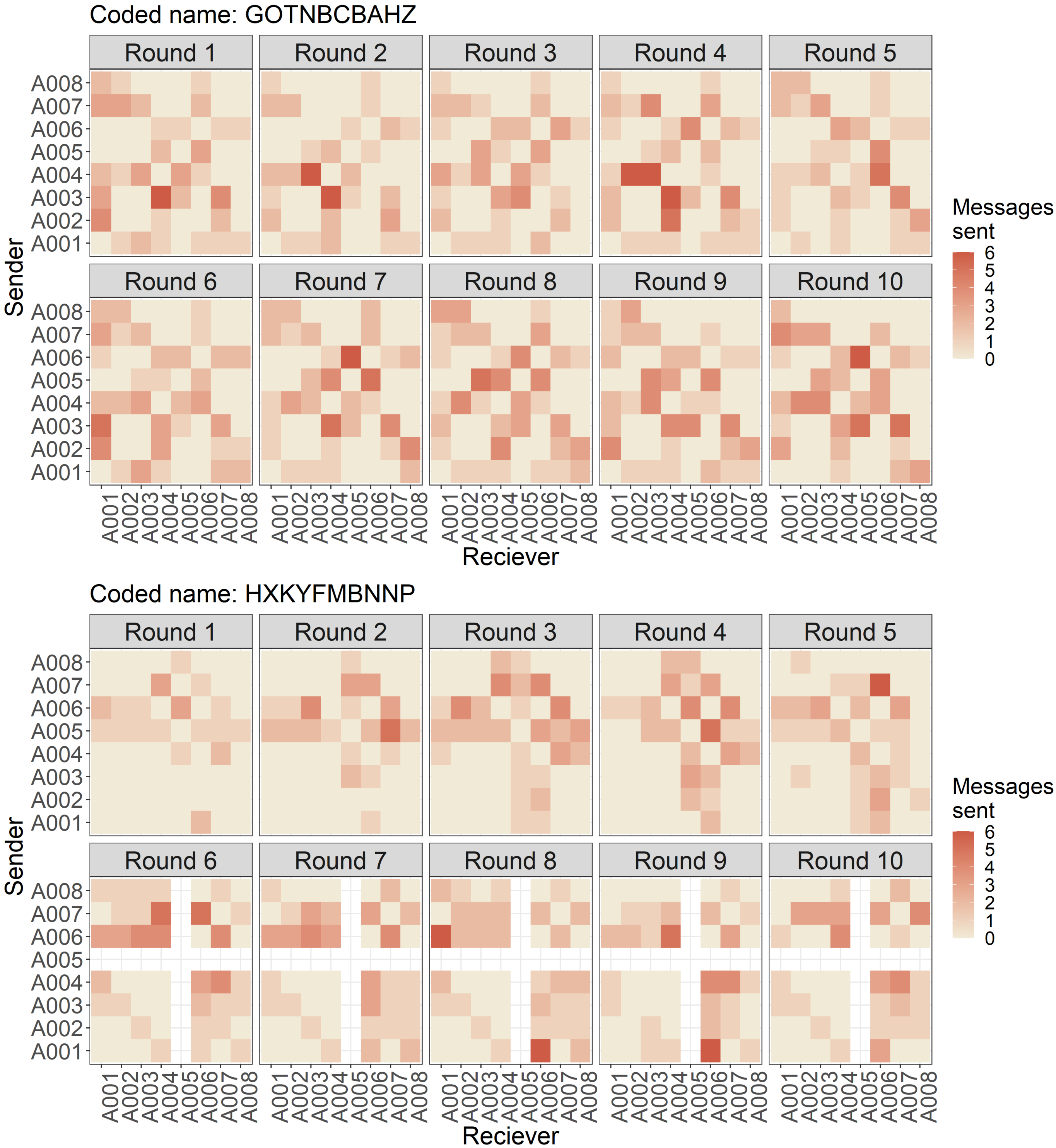
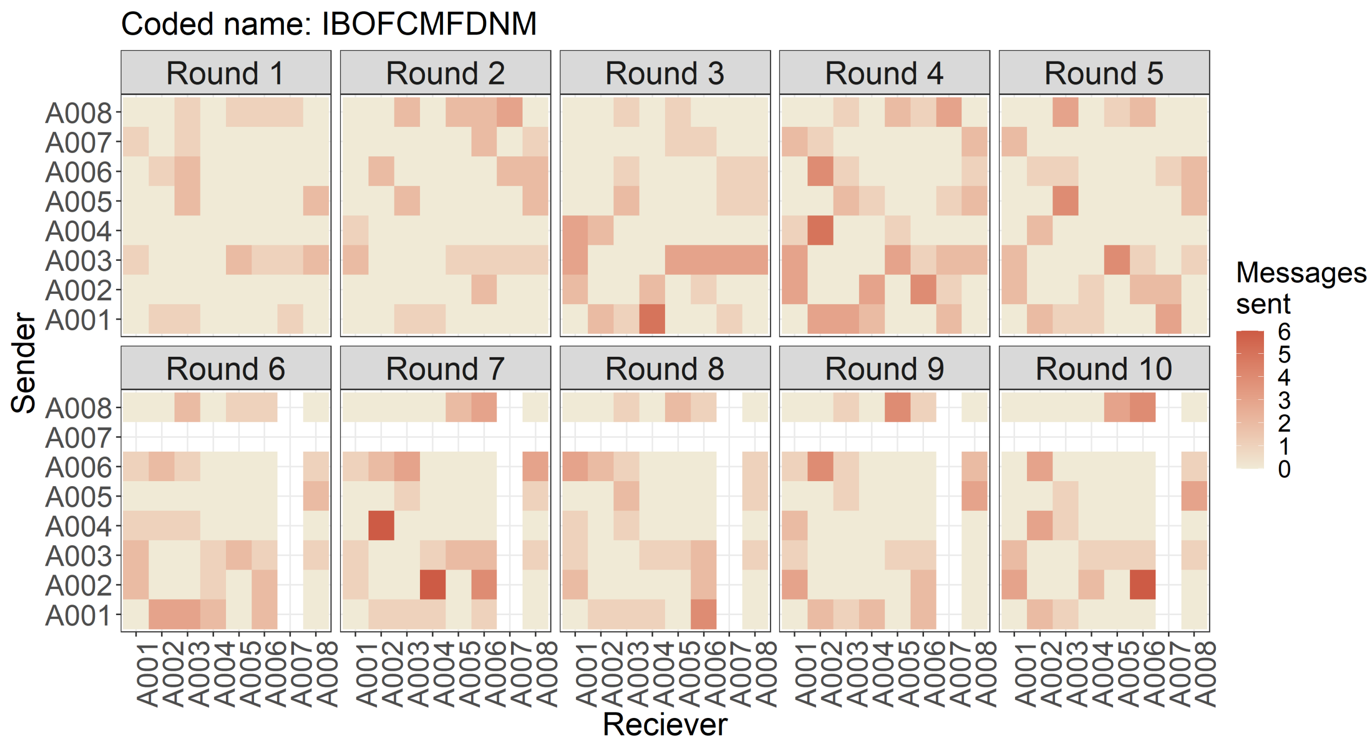


Figure 14: Communication frequency networks for teams 15-16.



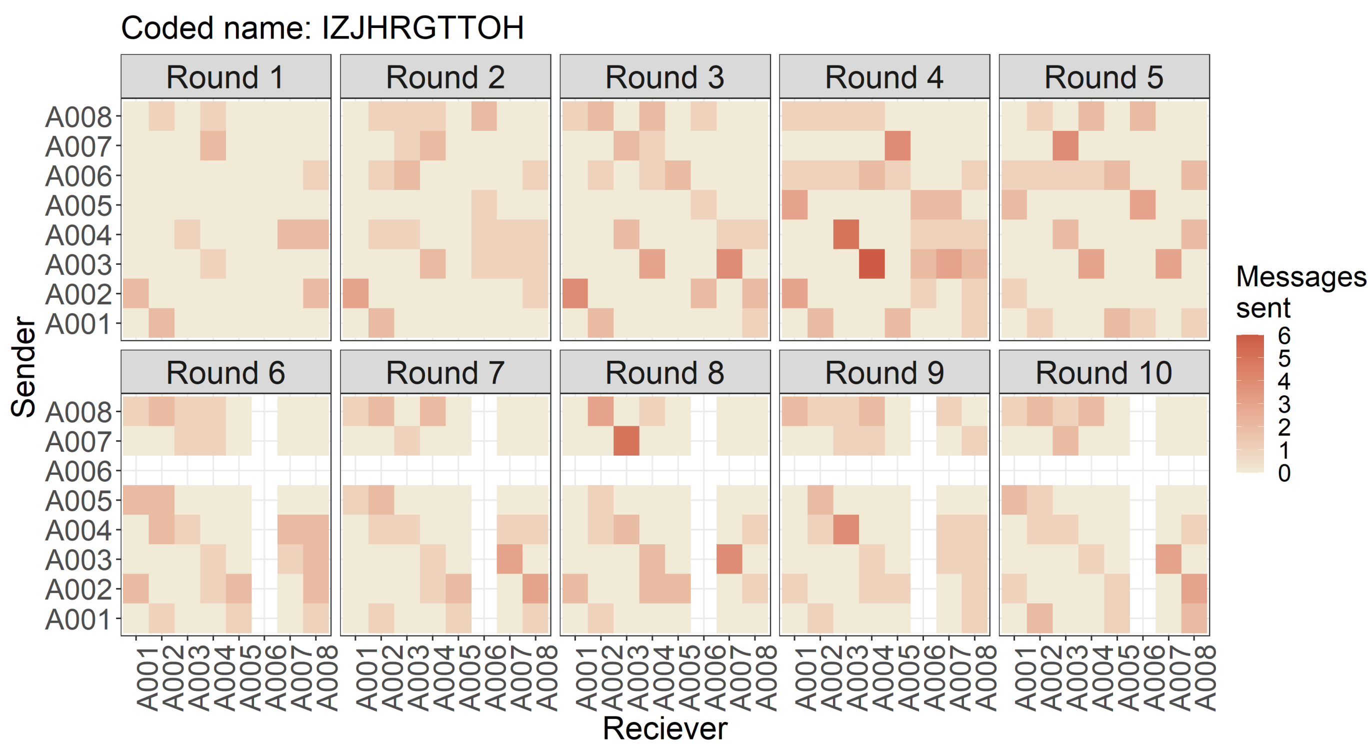
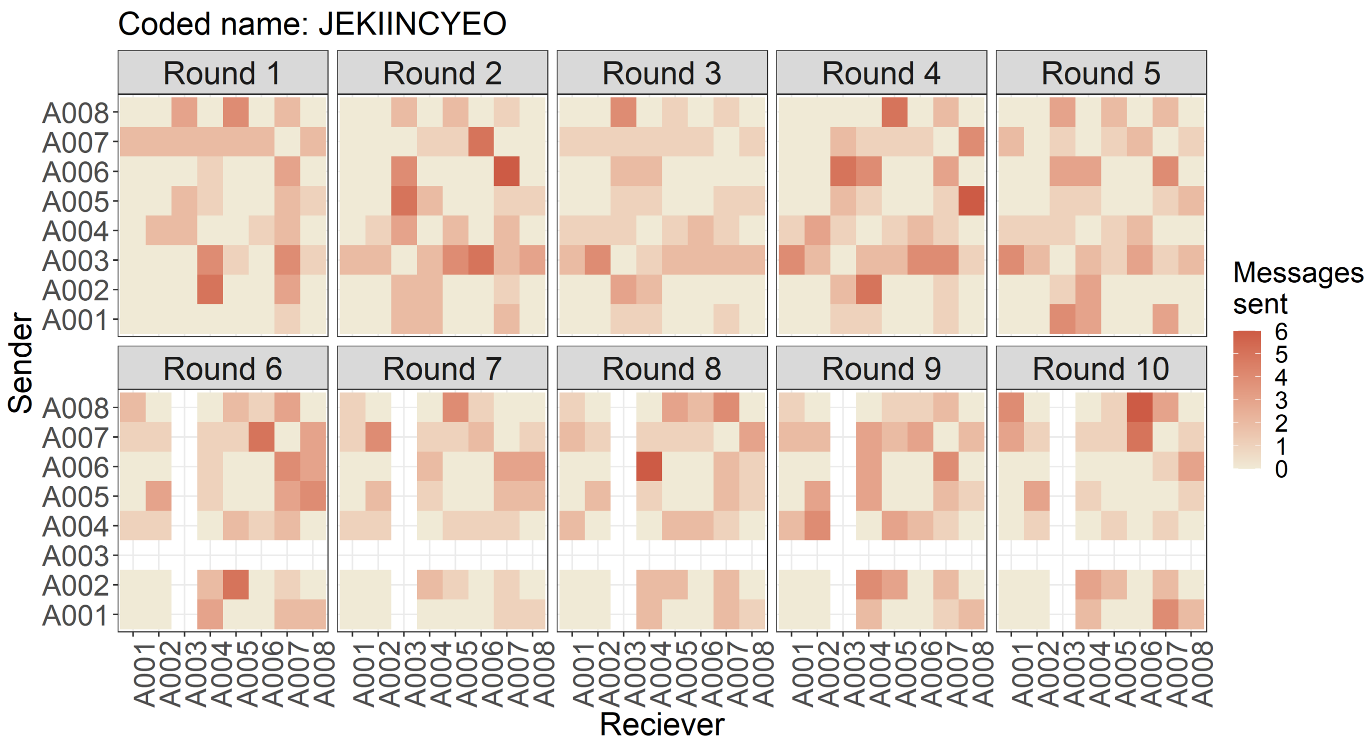


Figure 15: Communication frequency networks for teams 17-18.



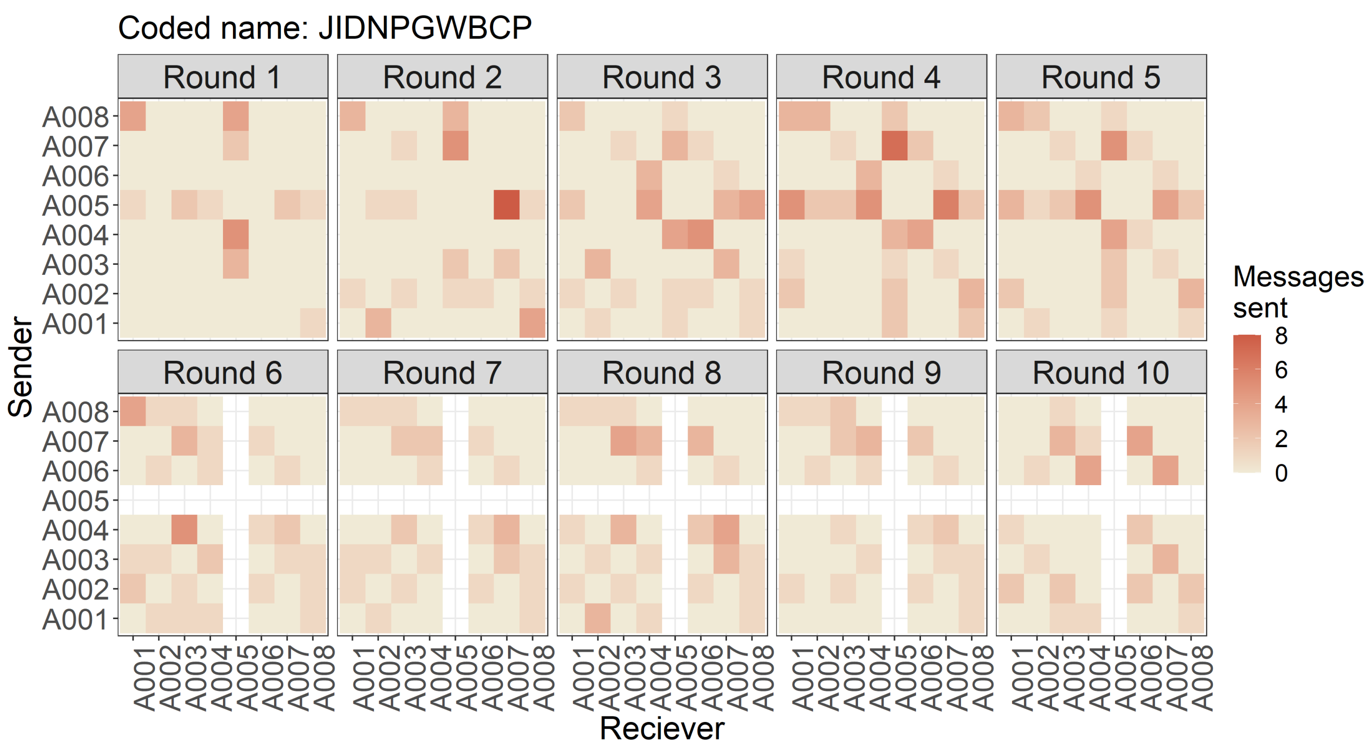


Figure 16: Communication frequency networks for teams 19-20.

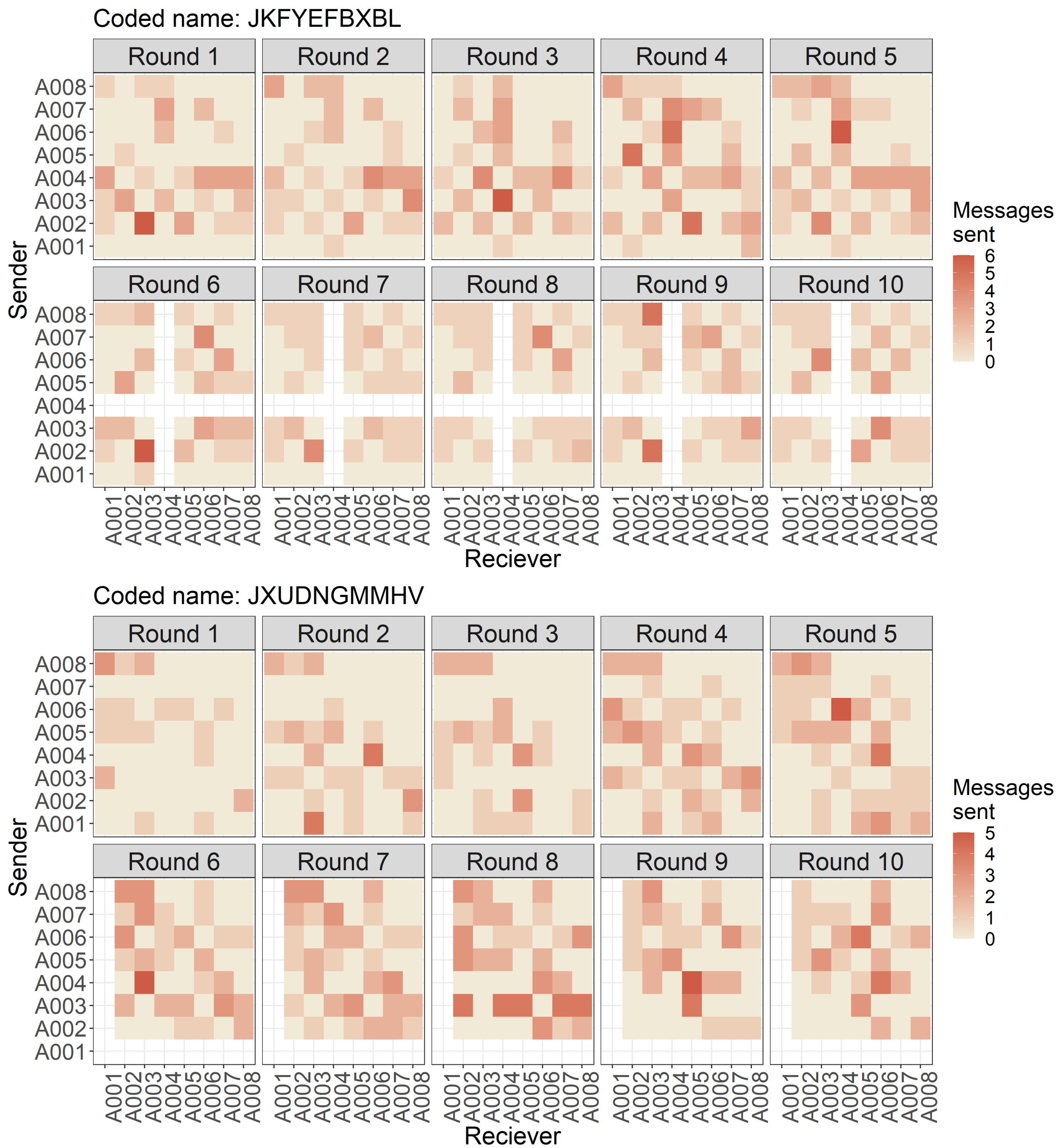
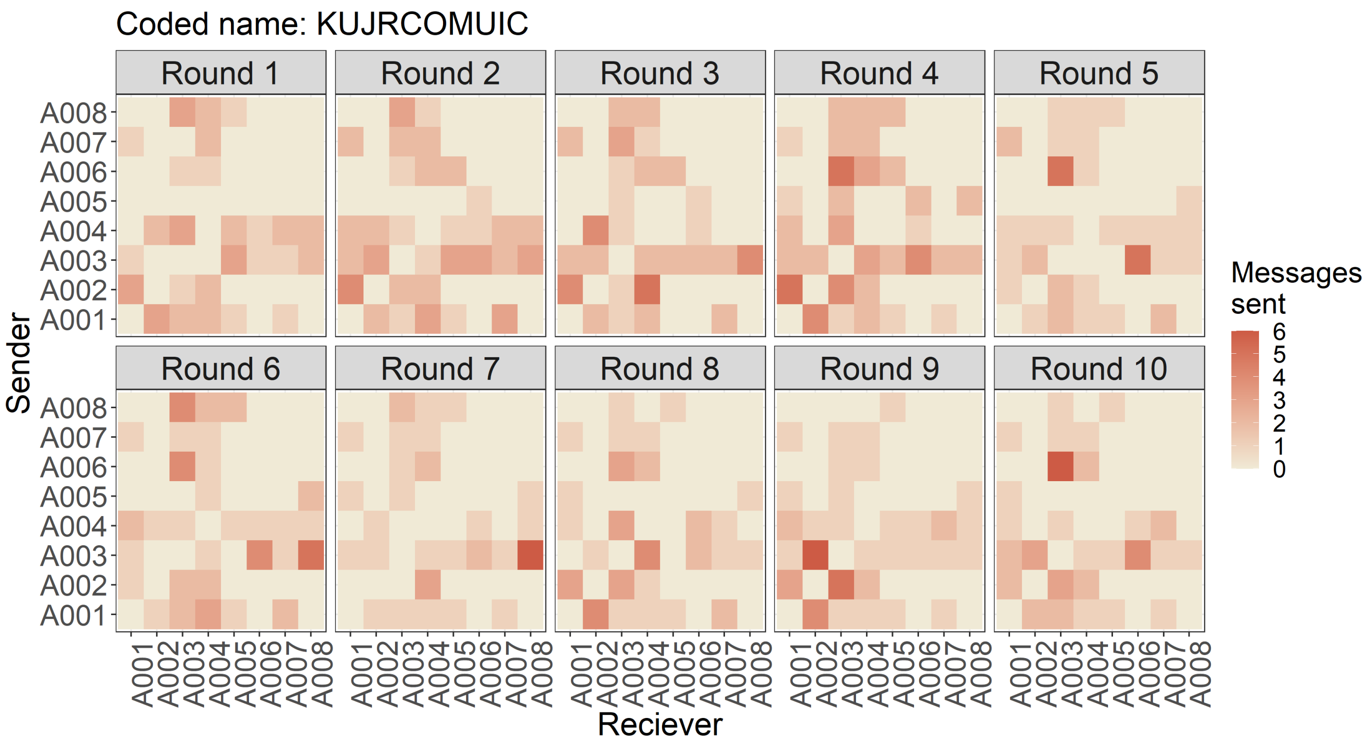


Figure 17: Communication frequency networks for teams 21-22.



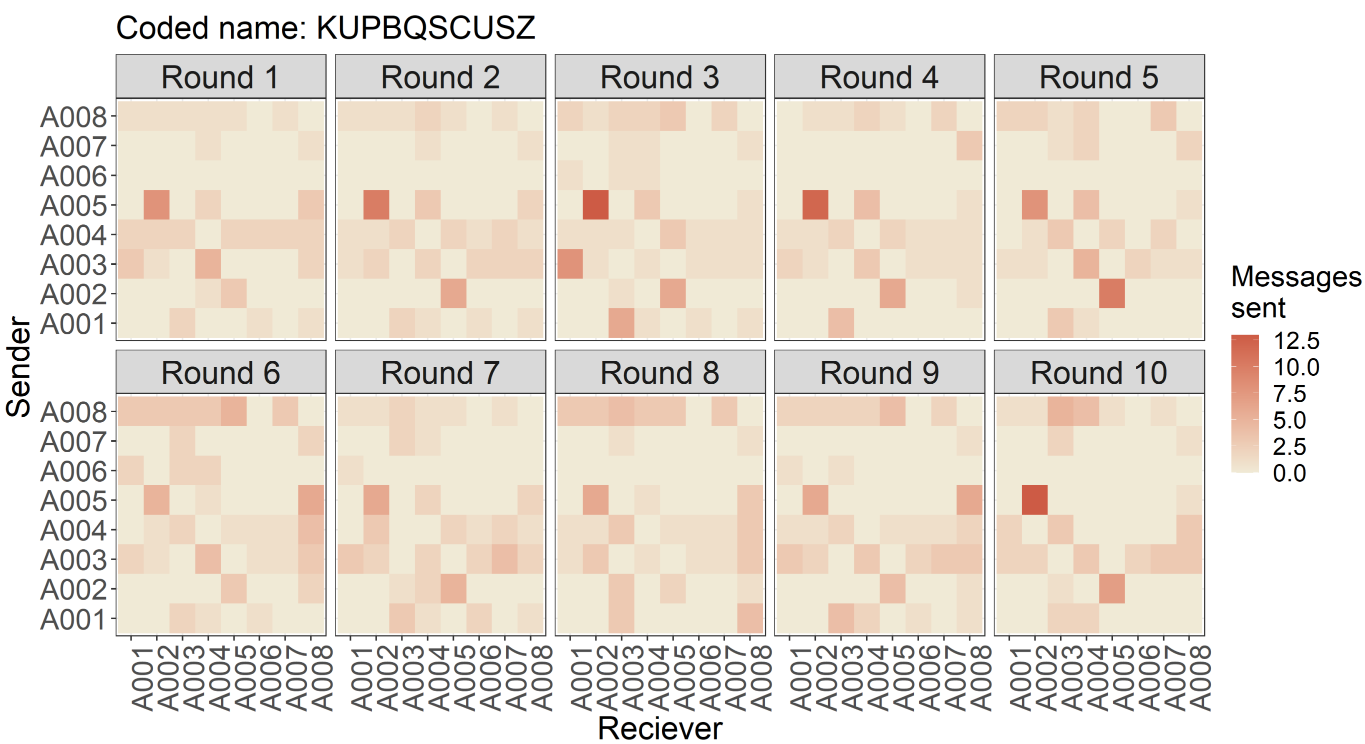


Figure 18: Communication frequency networks for teams 23-24.

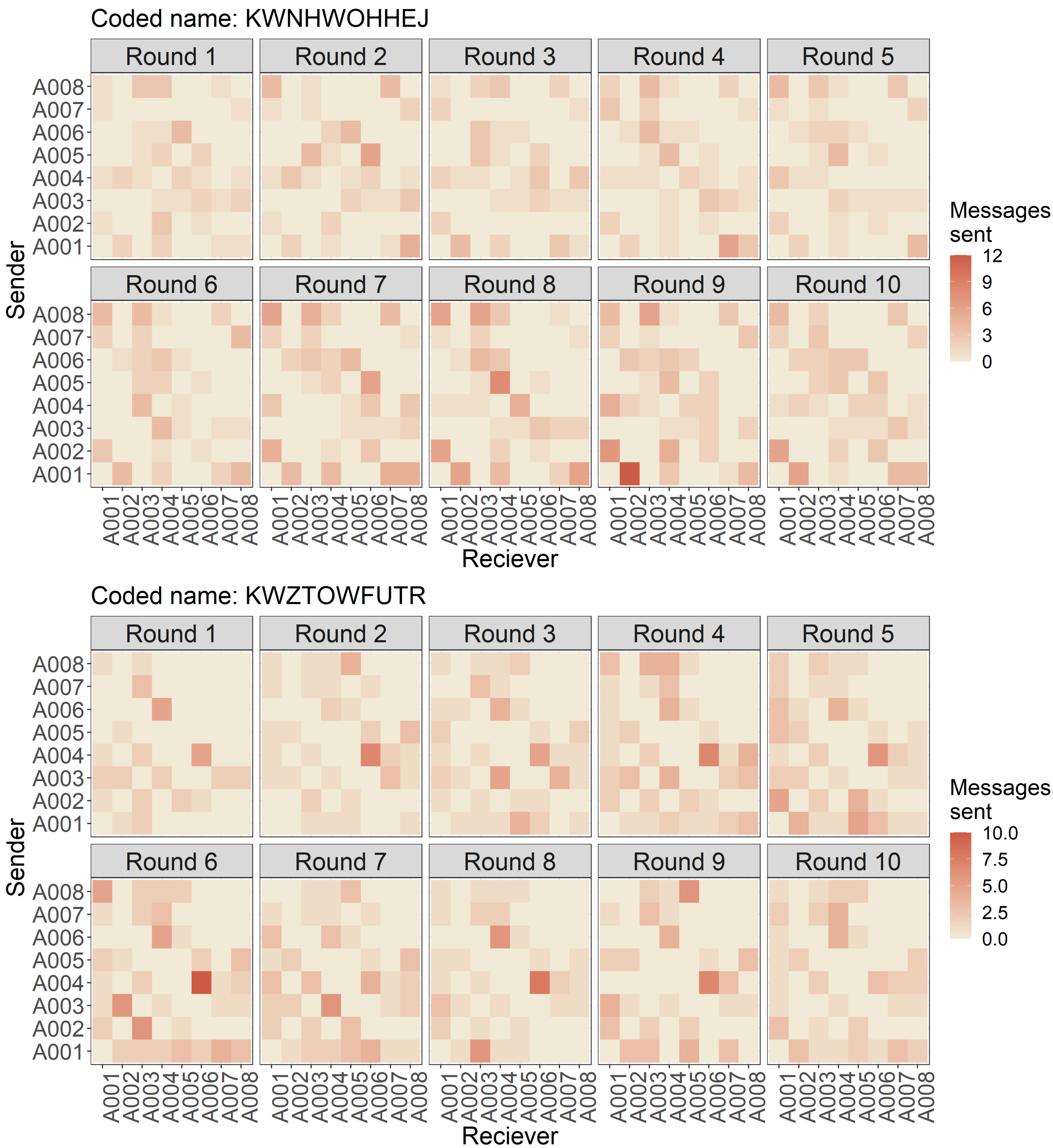


Figure 19: Communication frequency networks for teams 25-26.

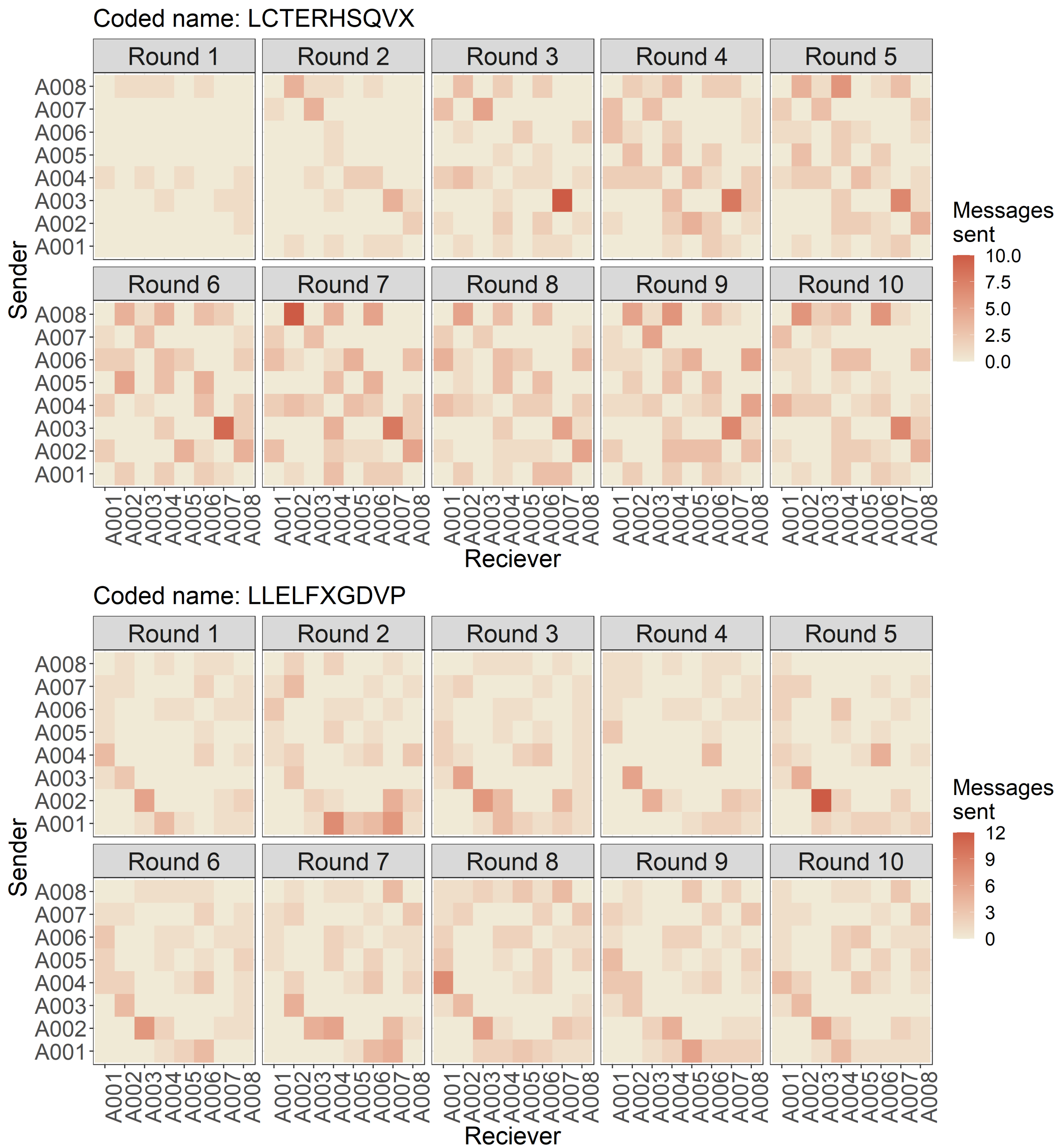


Figure 20: Communication frequency networks for teams 27-28.

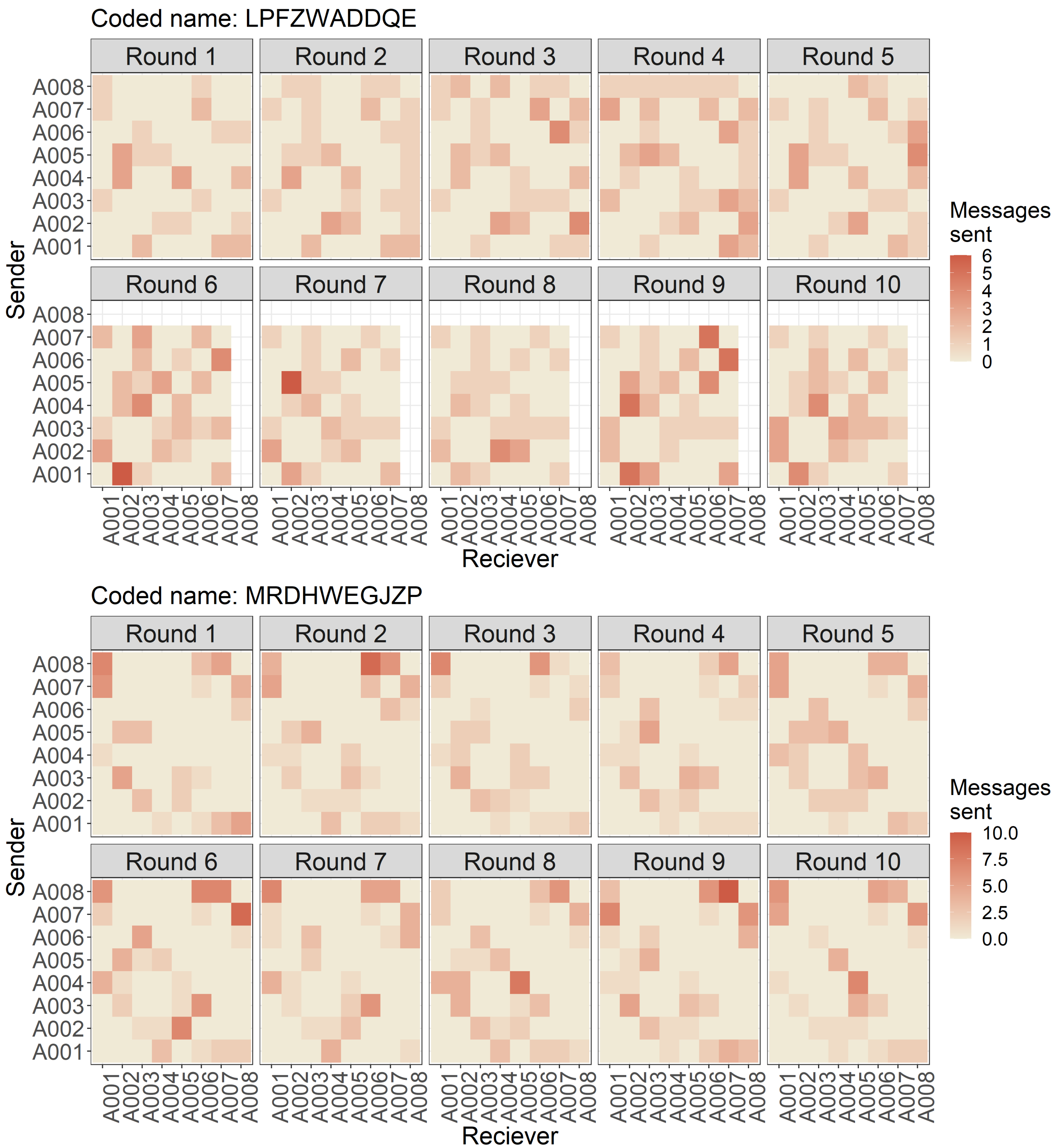


Figure 21: Communication frequency networks for teams 29-30.

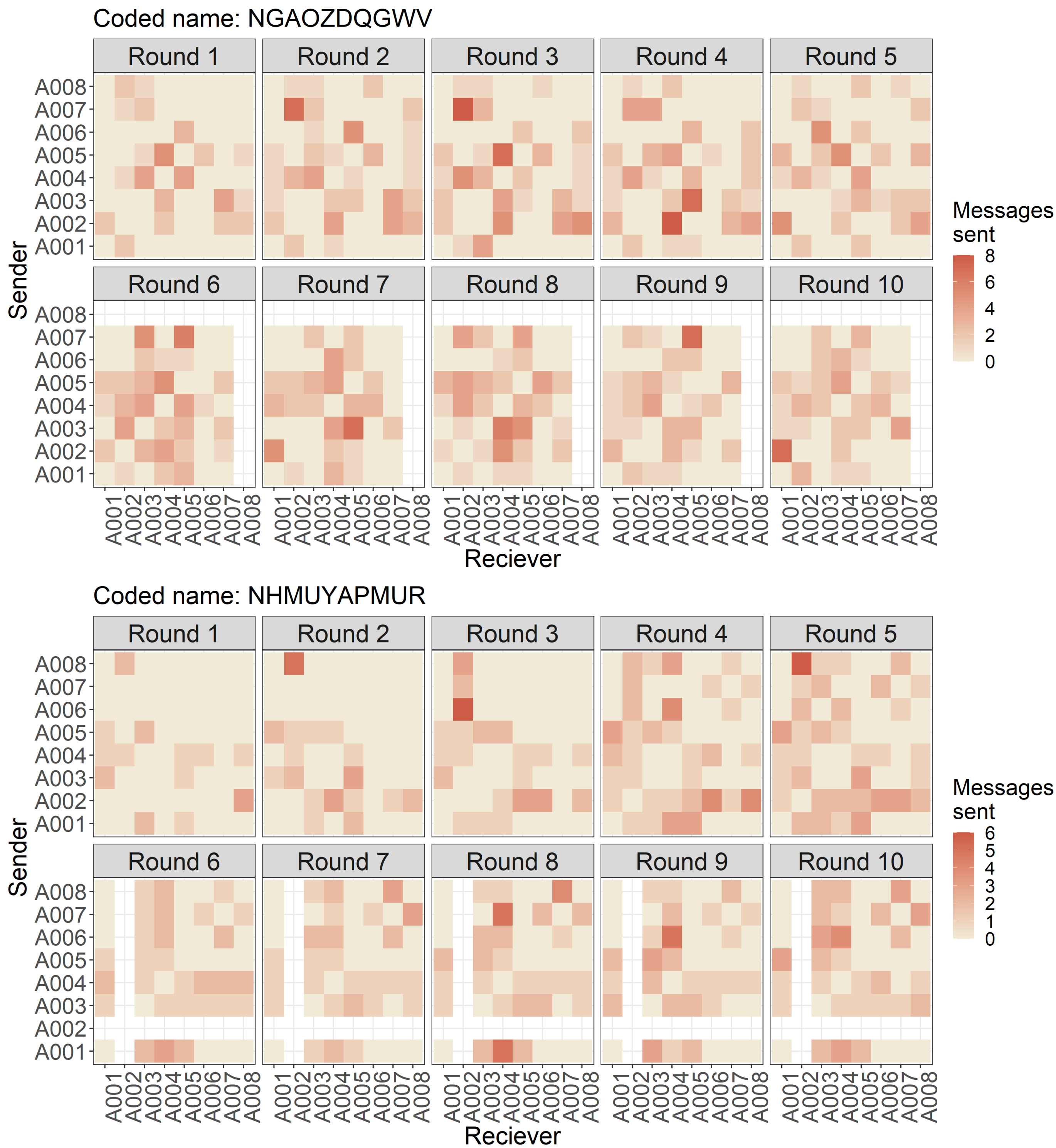


Figure 22: Communication frequency networks for teams 31-32.

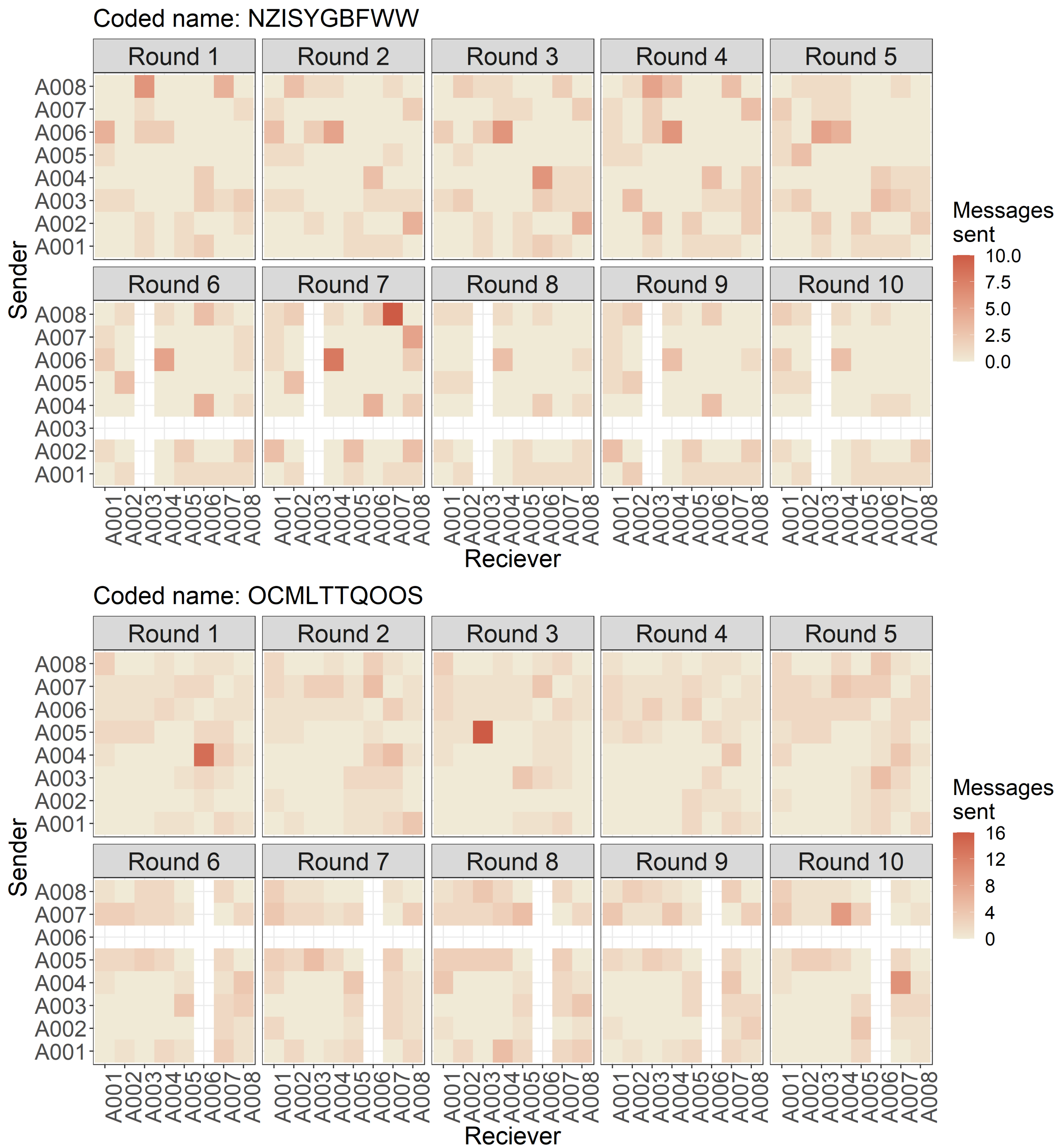


Figure 23: Communication frequency networks for teams 33-34.

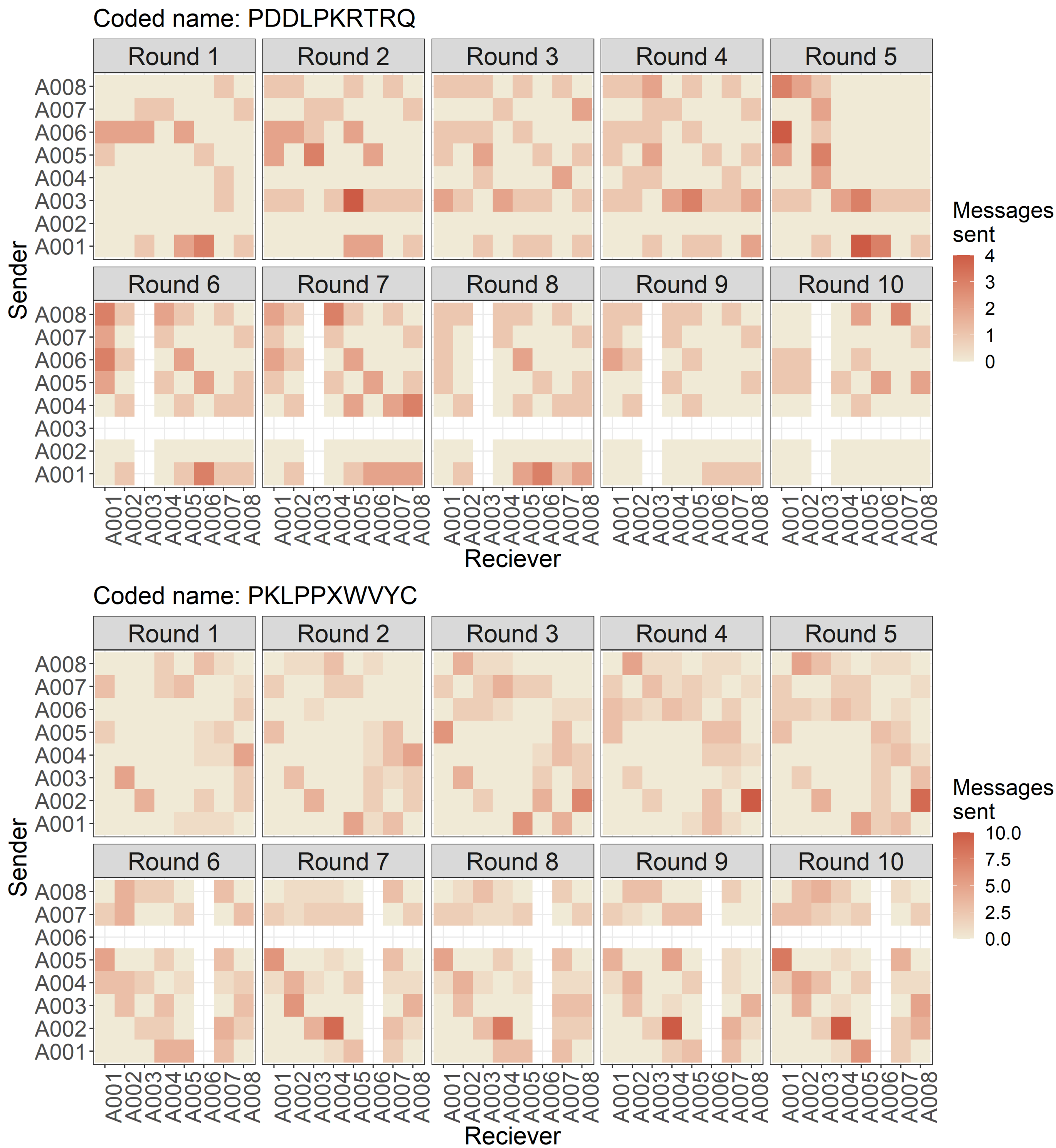


Figure 24: Communication frequency networks for teams 35-36.

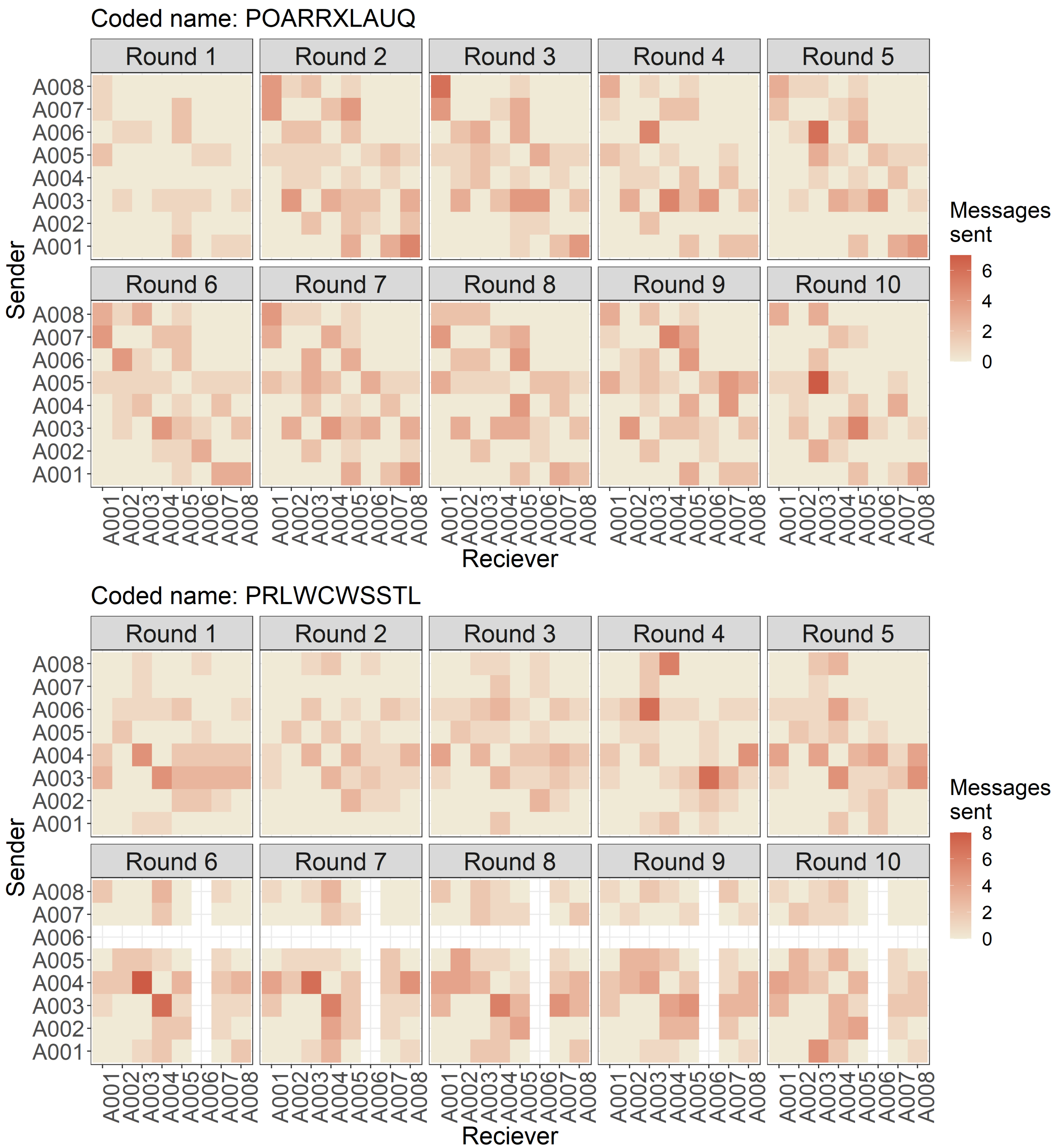


Figure 25: Communication frequency networks for teams 37-38.

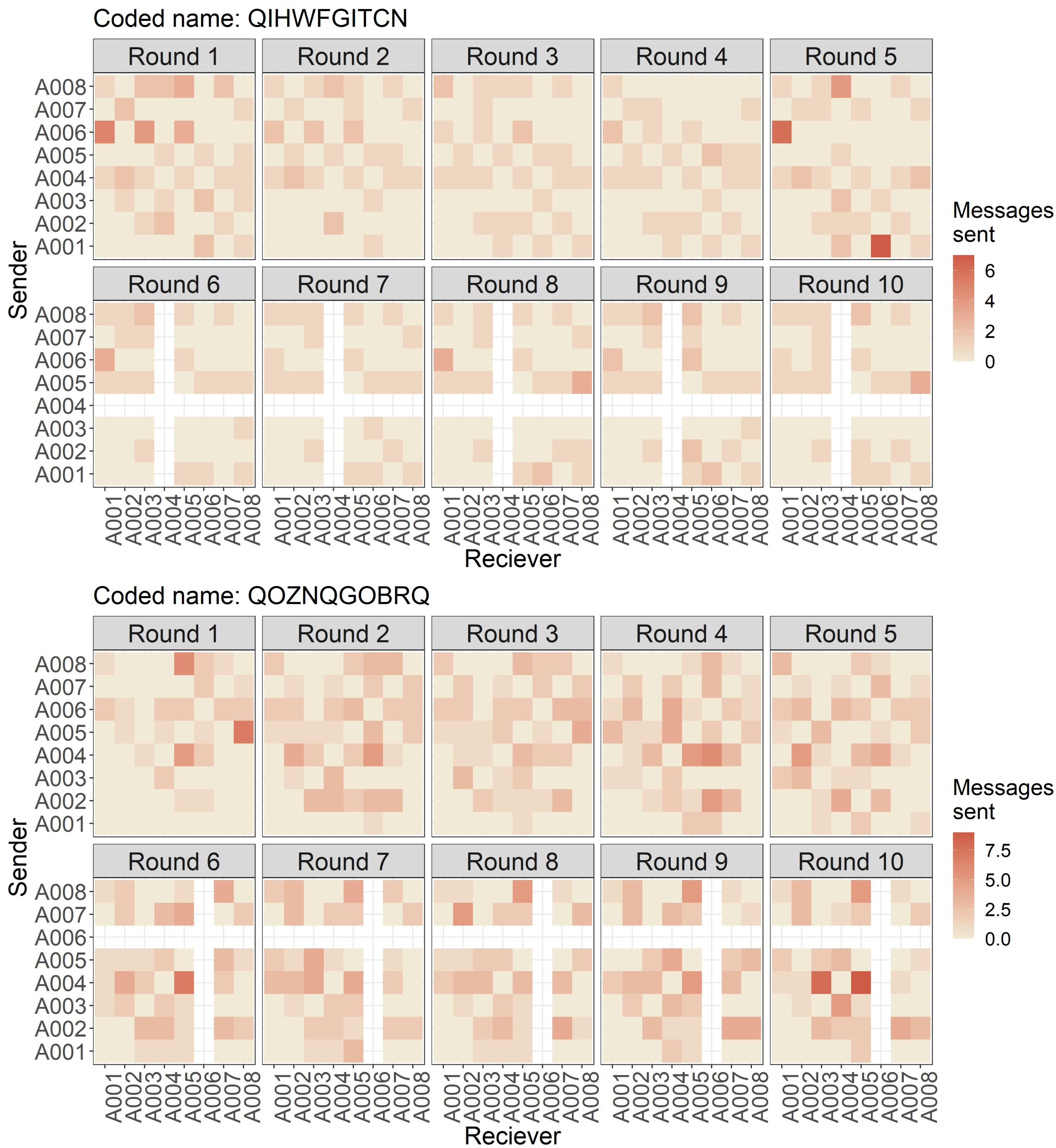


Figure 26: Communication frequency networks for teams 39-40.

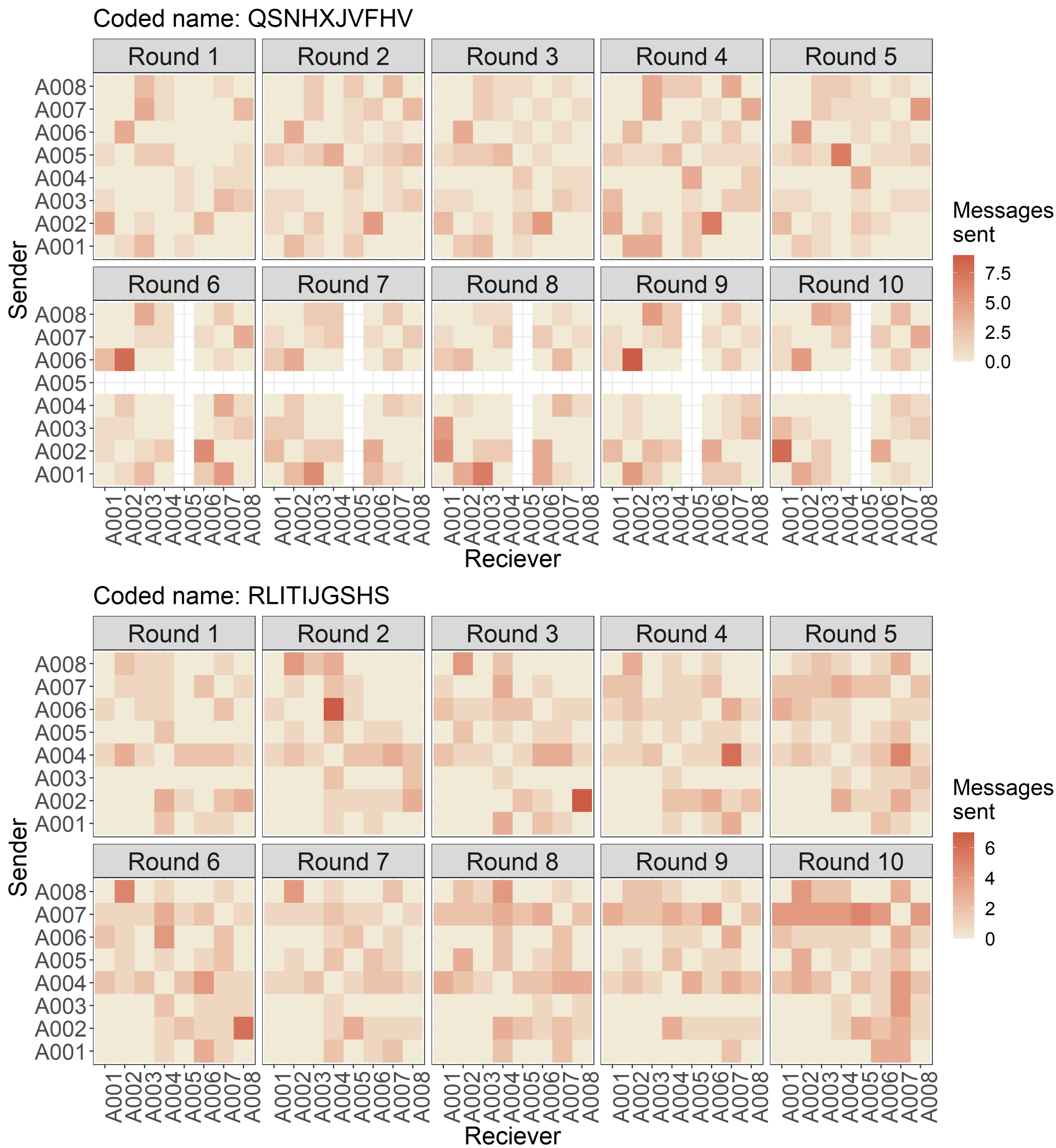
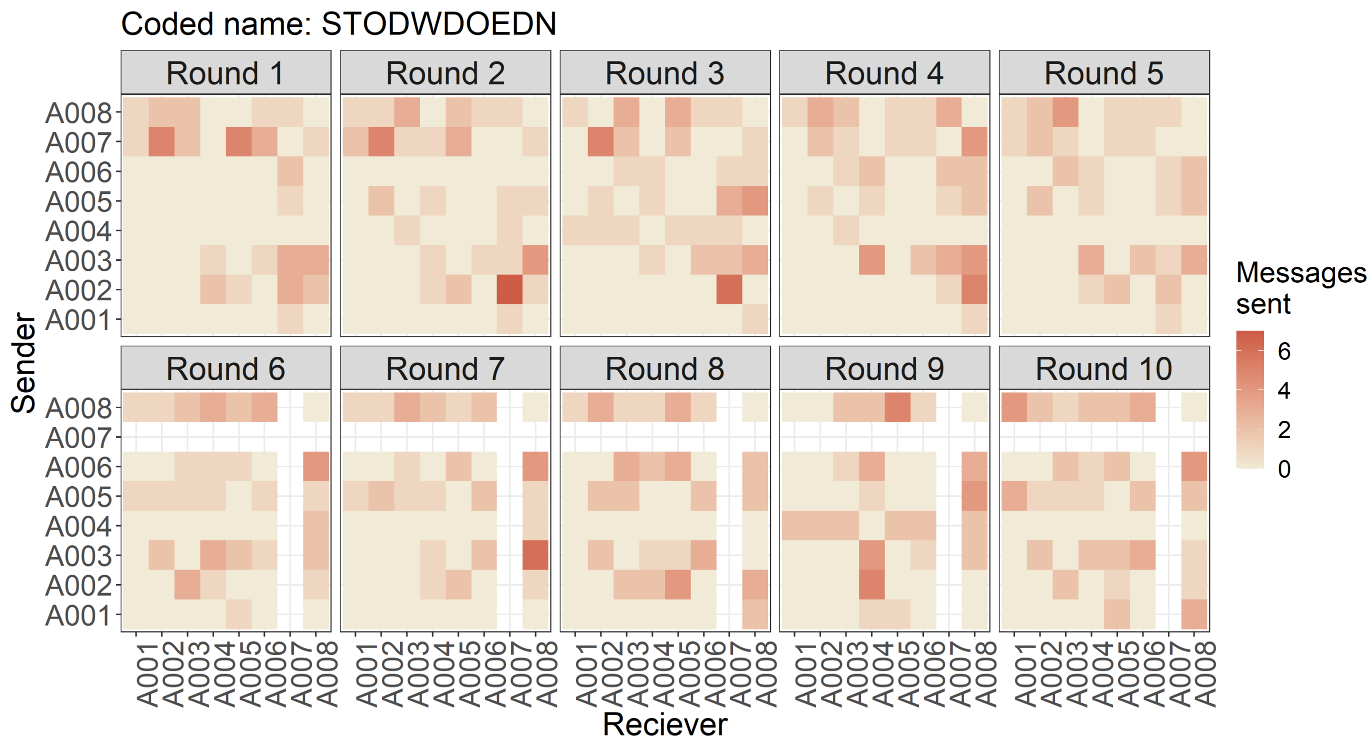


Figure 27: Communication frequency networks for teams 41-42.



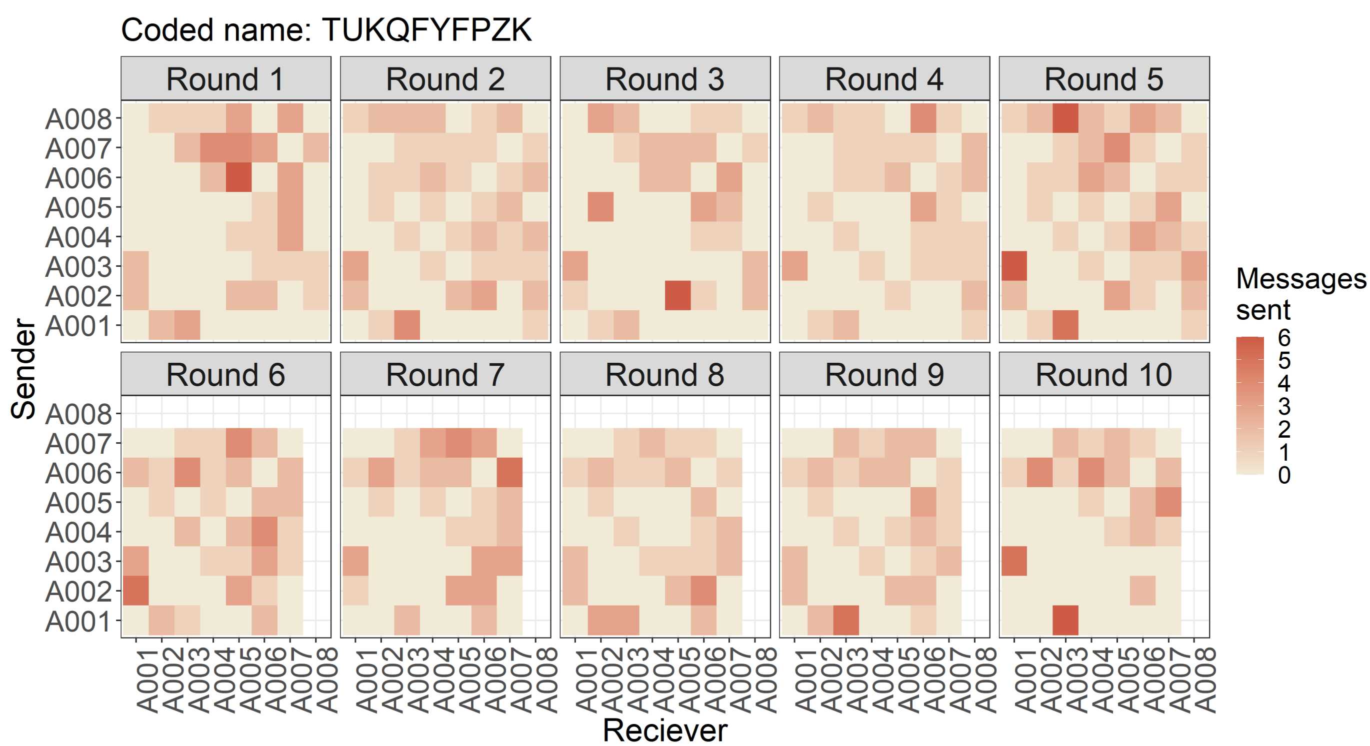
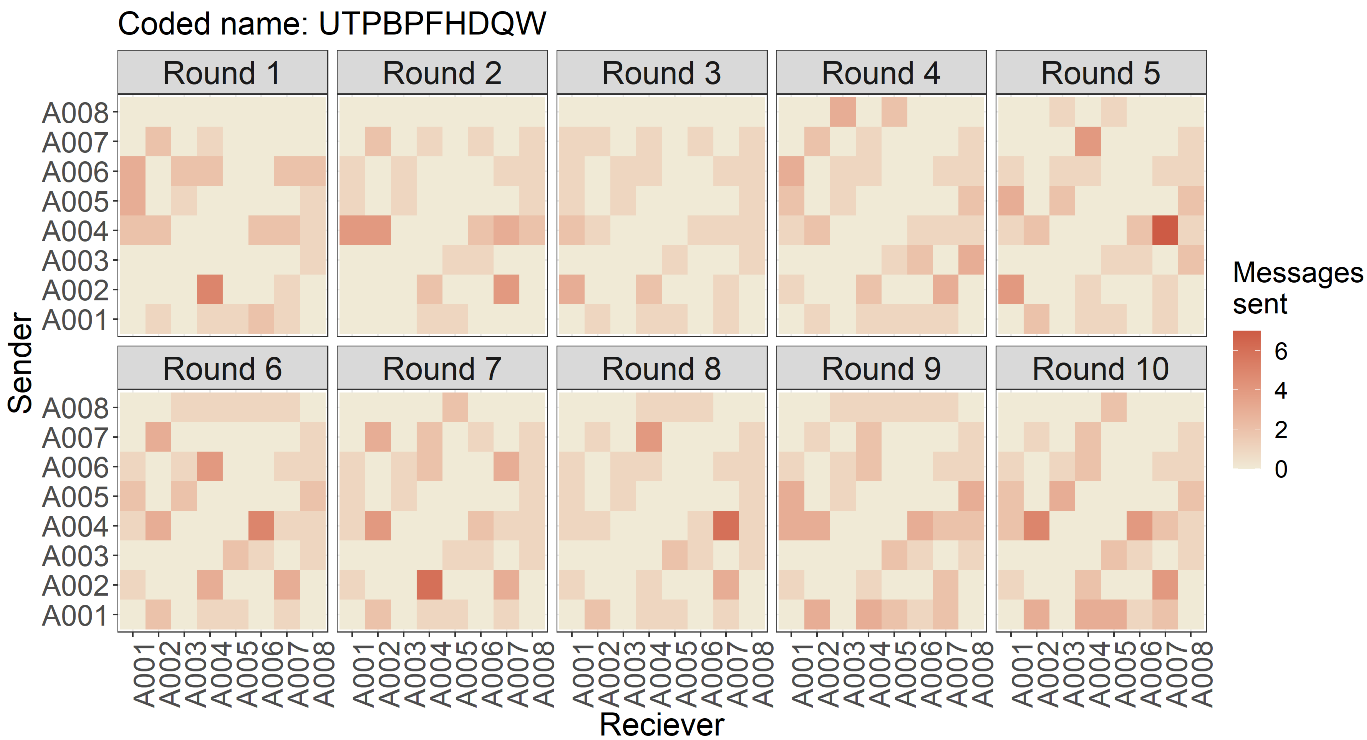


Figure 28: Communication frequency networks for teams 43-44.



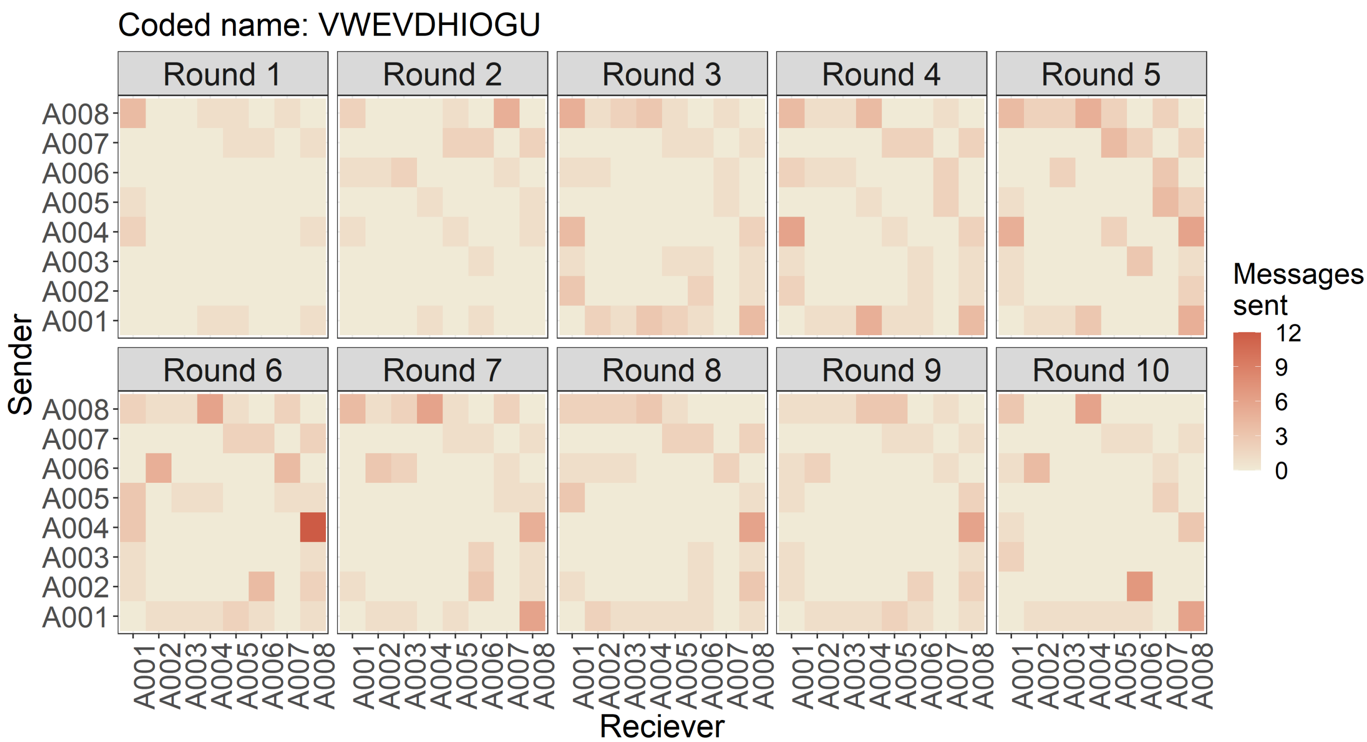


Figure 29: Communication frequency networks for teams 45-46.

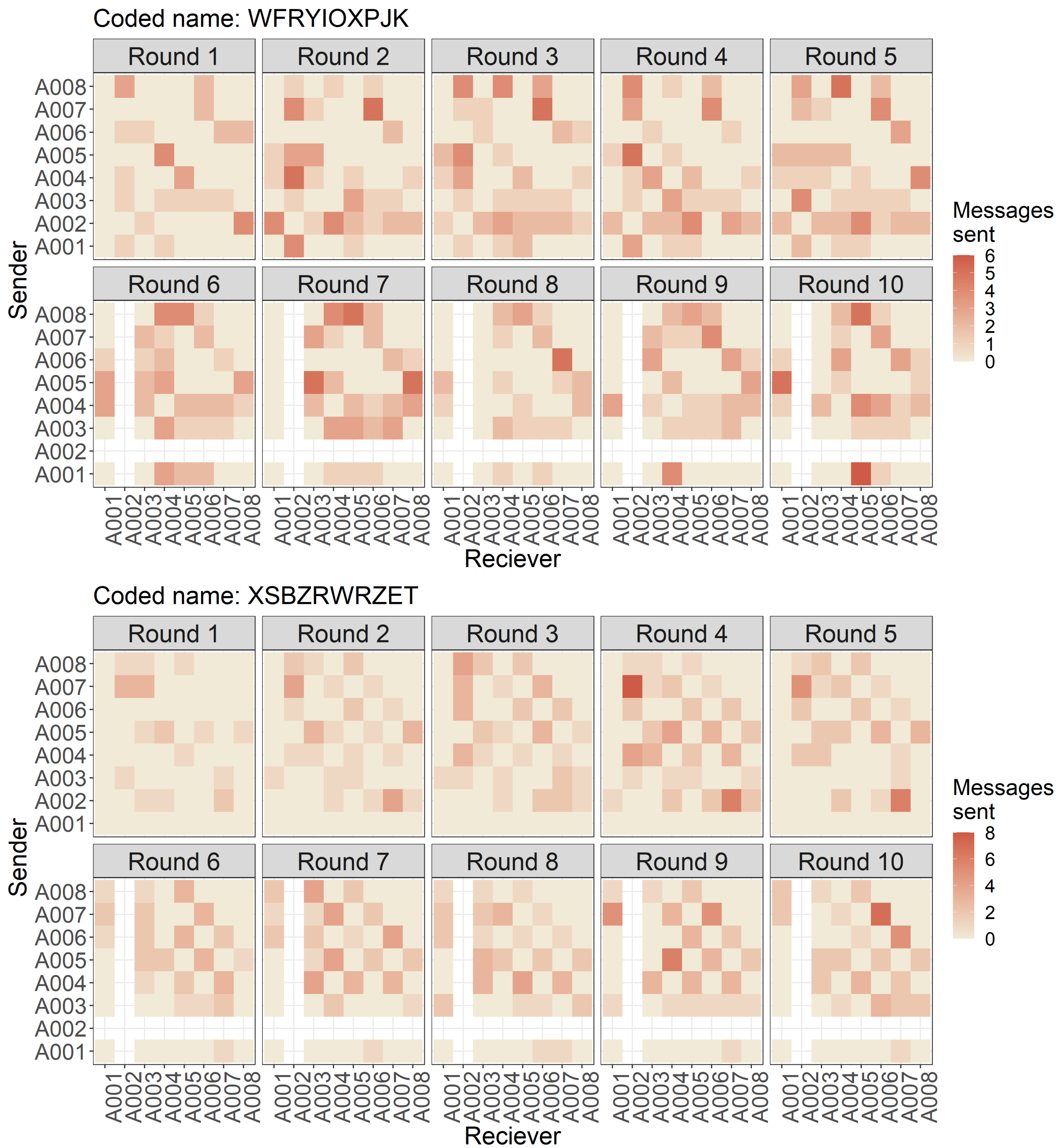


Figure 30: Communication frequency networks for teams 47-48.

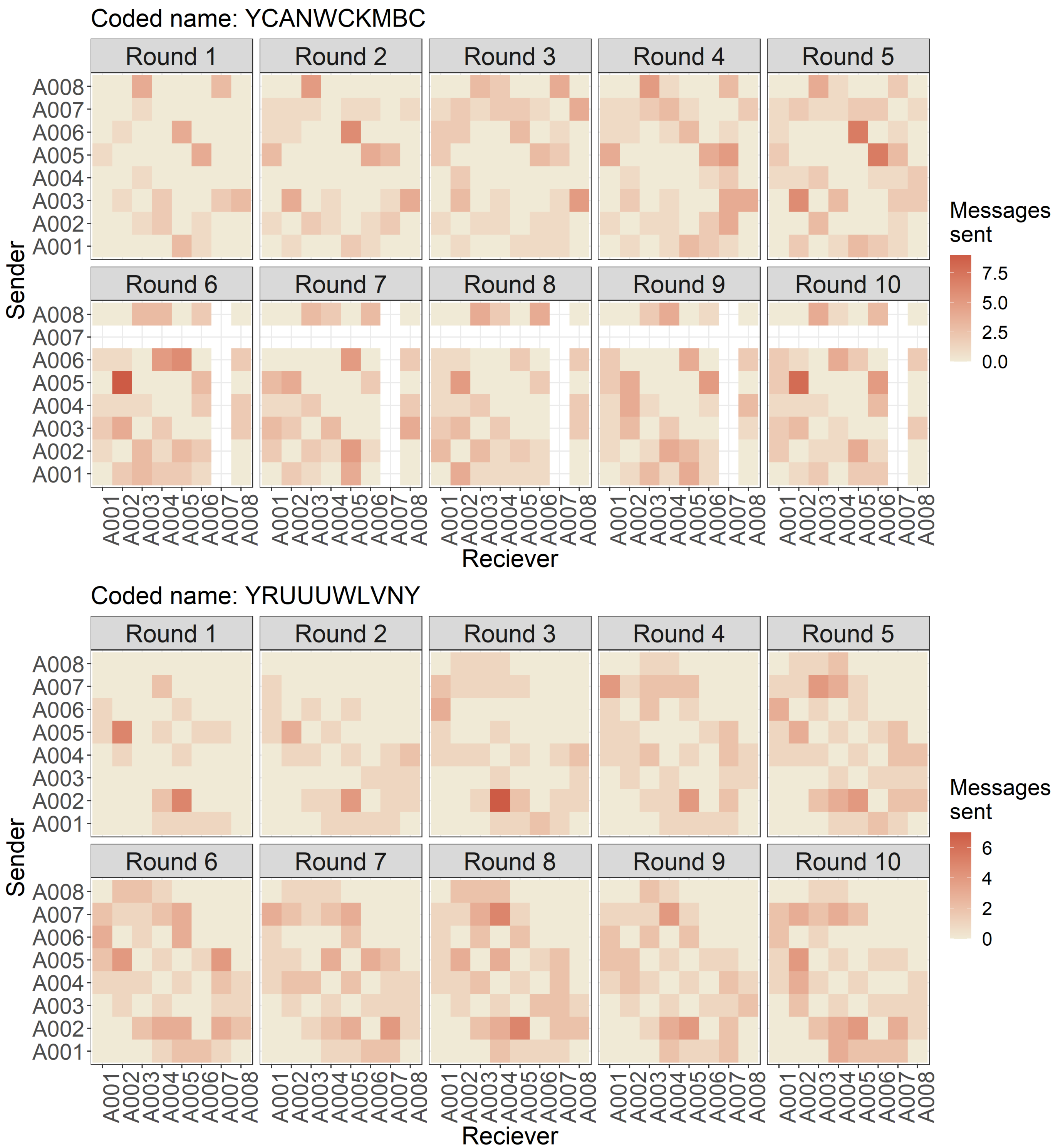
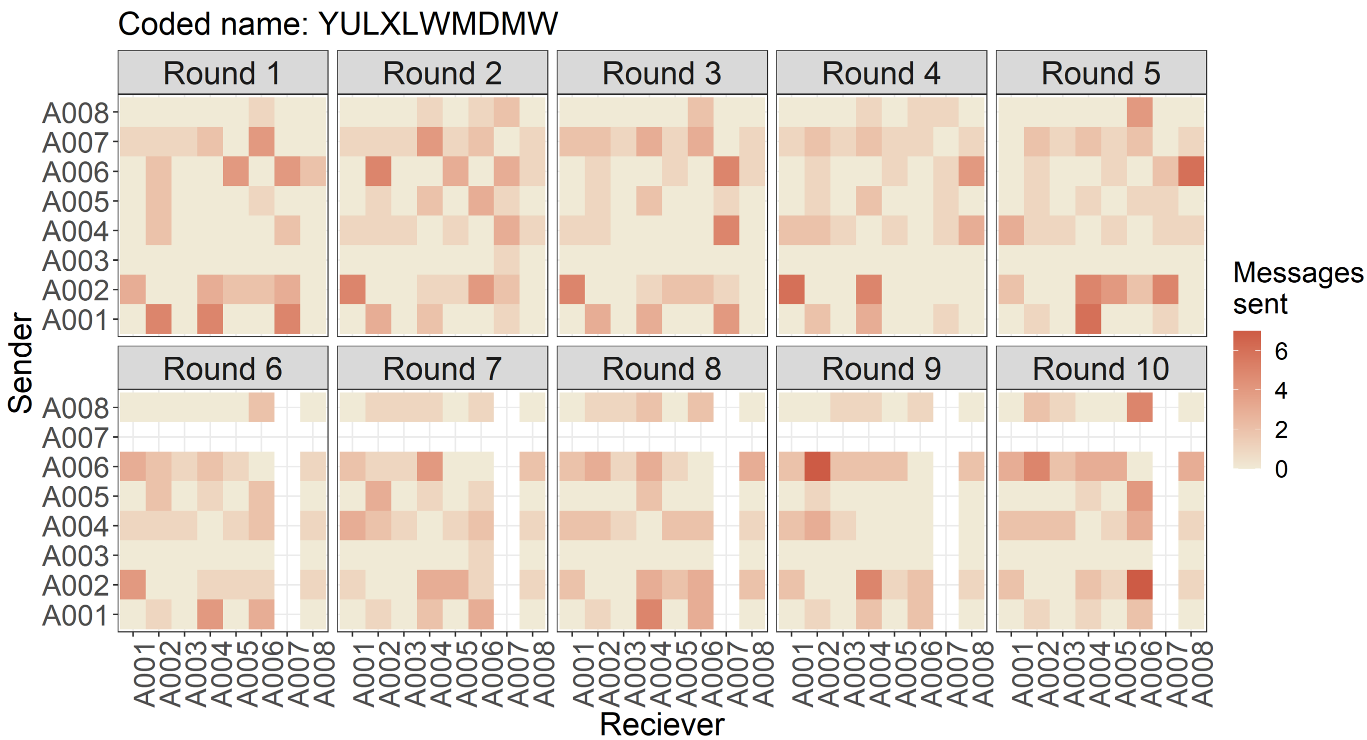


Figure 31: Communication frequency networks for teams 49-50.



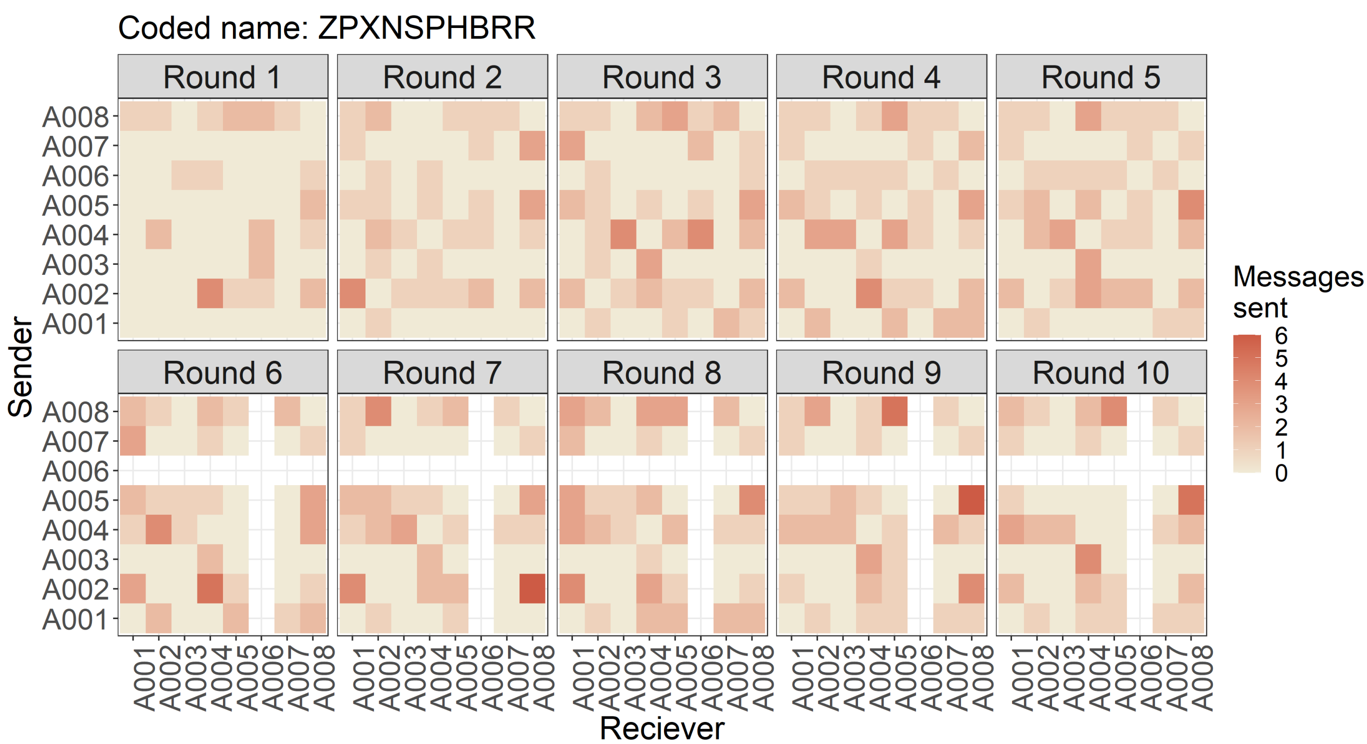


Figure 32: Communication frequency networks for teams 51-52.

Table 4: Alternative dependent variables to assess the affect of exogenous shocks on team performance. We find similar results to the manuscript.

	Team record	Messages	log(Messages)
Diff-in-diff ATE	−0.01	−12.73***	−0.23***
	(0.09)	(2.60)	(0.06)
Time	0.23***	11.63***	0.22***
	(0.07)	(2.08)	(0.05)
Knockout	0.08	−2.32	−0.06
	(0.06)	(1.84)	(0.04)
Constant	1.11***	51.78***	3.92***
	(0.05)	(1.47)	(0.03)
R^2	0.06	0.13	0.11
Num. obs.	520	520	520

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

3 Model fit

In the manuscript, we perform standard and random effects difference in difference regressions to assess how node knockouts affect teams and the remaining participants. Here were provide visualization of the random intercepts for each team in the team level and individual levels model. This helps us evaluate if the random effects for each team had good convergence properties. Figure 33 and 34 display the random team intercepts for the team and individual level models respectively. The random effects appear reasonable.

4 Alternative team level dependent variables

In the main text, we use the team record and normalized volume of messages sent. In this section, we replicate our analysis and use alternative dependent variables: (a) number of battlefields won, (b) total messages, and (c) log of total messages. Table 4 displays the alternative models. Across, all three models, we find similar results to the manuscript.

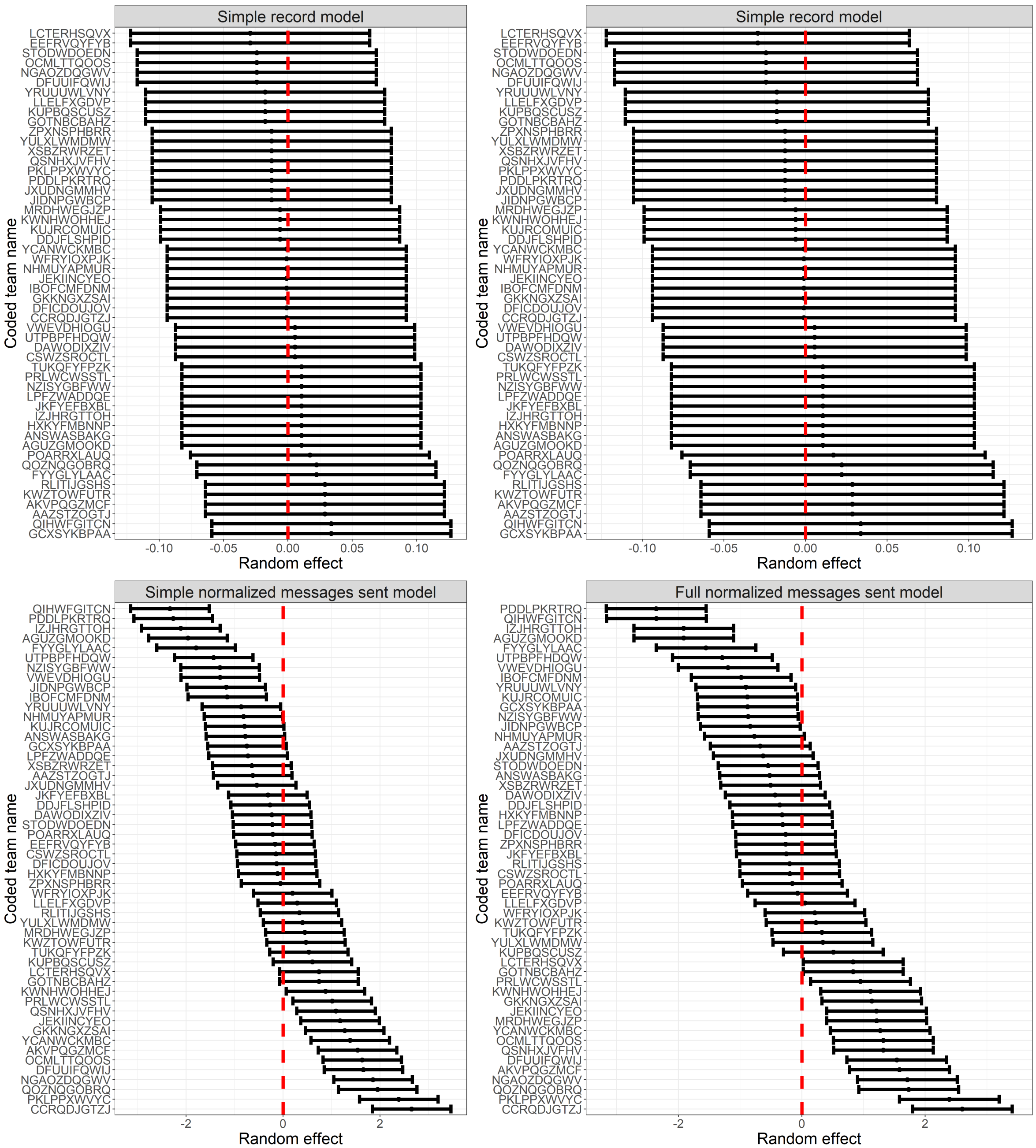


Figure 33: Random effects for the team level models: simple record, full record, simple normalized messages, and full normalizes messages.

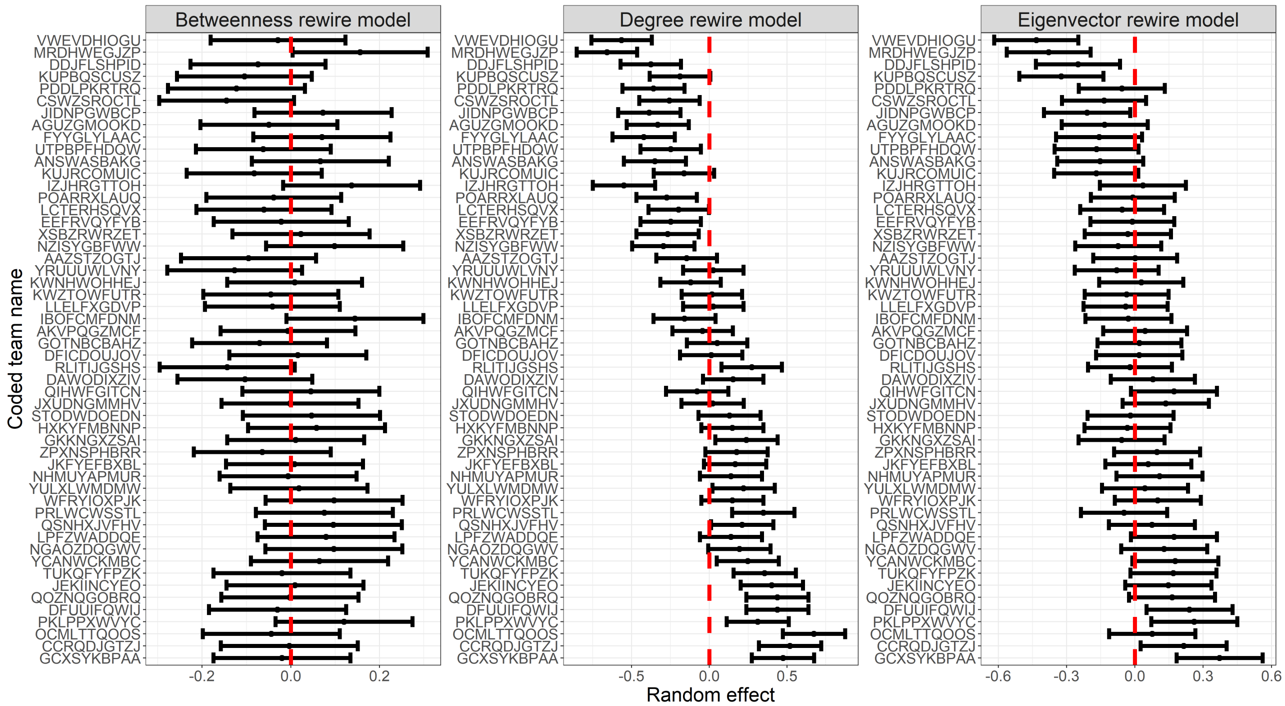


Figure 34: Random effects for the individual level models: changes in the degree, betweenness, and eigenvector centrality.

5 Alternative individual level dependent variables

In the manuscript, we assess for changes among players that rewired their network for their degree, betweenness, and eigenvector centrality after the knockout. In this section, we replicate the main models but use authority score as a dependent variable. The authority score of a participant is calculated by summing the hub scores (i.e. how much information) is being shared by their chat partners. This measure is used to evaluate how many connections a node has to other nodes which have important information in the network. In the context of the experiment, this measure evaluates if the participant is more connected to the team leaders following the knockout treatment. Table 5 displays the model results.

Table 5: Alternative dependent variables for the effect of network rewiring on the remaining participants contributions to the communication frequency network.

	Authority score	
	Diff-in-diff	Random effects regression
Diff-in-diff ATE	0.21***	0.19**
	(0.06)	(0.06)
Time	0.03	0.06
	(0.04)	(0.04)
Knockout	−0.15***	−0.29***
	(0.04)	(0.05)
Constant	0.00	0.07
	(0.03)	(0.04)
Team random effects	−−	✓

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Table 6: Logistic regression difference in difference estimate of the node knockout on team record.

	Team record	
	Diff-in-diff	Random effects regression
Diff-in-diff ATE	−0.24	−0.24
	(0.44)	(0.44)
Time	1.17**	1.18**
	(0.36)	(0.36)
Knockout	0.44	0.45
	(0.35)	(0.35)
Constant	−1.76***	−1.77***
	(0.29)	(0.30)
Team random effects	−−	✓

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

6 Alternative team level model specifications

6.1 Logistic transformation

In the manuscript, we assess for changes in team performance using team record. This dependent variable is zero or one. For the ease of interpretation, we used a linear probability model in the manuscript. Here, we replicate the manuscript model using a logistic regression transformation.Table 6 displays the regression results. Across both models, we similarly find that the node knockout decreases team performance but is not statistically significant.

Table 7: Replication of the main models from the manuscript but with random effects included for teams and round.

	Team record	Normalized messages
Diff-in-diff ATE	-0.02	-0.73^{***}
	(0.08)	(0.22)
Time	0.21^{**}	1.45^{**}
	(0.08)	(0.50)
Knockout	0.06	-0.29
	(0.06)	(0.40)
Constant	0.15^{**}	6.47^{***}
	(0.06)	(0.46)
AIC	653.12	1829.99
BIC	682.89	1859.76
Log Likelihood	-319.56	-907.99
Num. obs.	520	520

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

6.2 Round random effects

In this subsection, we replicate the findings in the manuscript but include random effects for each round to see if round heterogeneity accounts for variation in team records and normalized messages sent. Table 7 reports the results. Similar to the main findings, node knockouts decrease the number of messages sent, while the effect of the node knockout on team record is negative but null.

7 Alternative individual level model specifications

7.1 Round and treatment random effects

In this subsection, we replicate the individual level main findings and add in round random effects. Table 8 reports the results. Across all models, the effect of the knockout is statistically significant and positive on the rewired players' communication frequency centrality.

7.2 No control teams

In the manuscript, we assess the effect of network rewiring against players on knocked out teams that did not rewire and on control teams where no player rewired their network. In this subsection,

Table 8: The rewire treatment on individuals degree, betweenness, and eigenvector centrality within their teams communication frequency network after rewiring their network with random effects for teams, round and treatment.

	Degree centrality	Betweenness centrality	Eigenvector centrality
Diff-in-diff ATE	0.21^{***}	0.13^{*}	0.31^{***}
	(0.06)	(0.06)	(0.06)
Time	0.12	-0.16^{***}	0.04
	(0.15)	(0.04)	(0.06)
Knockout	-0.64^{***}	-0.46^{***}	-0.34^{***}
	(0.05)	(0.05)	(0.05)
Constant	$0.20^{\cdot}$	0.27^{***}	0.07
	(0.12)	(0.03)	(0.05)
AIC	10747.76	11232.44	11245.40
BIC	10791.81	11276.49	11289.45
Log Likelihood	−5366.88	−5609.22	−5615.70
Num. obs.	3995	3995	3995
Num. groups: Teams	52	52	52
Num. groups: Round	10	10	10

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

we replicate the individual level analysis with only teams that experienced a knockout. Table 9 reports the results. Across all models, the effect of rewiring a network is statistically significant and positive on a players degree, betweenness, and eigenvector centrality.

7.3 Second order density and degree centralization

In the manuscript, we assess the effect of communication network density and degree centralization on team performance, operationalized as team record and normalized volume of messages sent. In this section, we model these processes again but include second order polynomials for these attributes as there may be a nonlinear effect. Table 10 displays the communication network density and degree centralization effects. In both models the first degree effect of communication network density and degree centralization is null, while the second order effect on normalized messages sent is statistically significant for communication network density. Similar to the main analysis, the treatment effect is statistically significant and negative for normalized volume of messages sent and team record.

Table 9: The rewire treatment on individuals degree, betweenness, and eigenvector centrality within their teams communication frequency network for only teams that had a knockout.

	Degree centrality	Betweenness centrality	Eigenvector centrality
Diff-in-diff ATE	0.62^{***}	0.58^{***}	0.42^{***}
	(0.09)	(0.09)	(0.09)
Time	-0.29^{***}	-0.61^{***}	-0.07
	(0.08)	(0.08)	(0.08)
Knockout	-0.76^{***}	-0.76^{***}	-0.46^{***}
	(0.06)	(0.06)	(0.06)
Constant	0.43^{***}	0.60^{***}	0.26^{***}
	(0.05)	(0.05)	(0.05)
R^2	0.07	0.08	0.04
Adj. R^2	0.07	0.08	0.04
Num. obs.	2475	2475	2475

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 10: Second order polynomial for communication network density and degree centralization.

	Normalized volume of messages sent	Record
Diff-in-diff ATE	-1.08^{***}	-0.03
	(0.28)	(0.09)
Time	1.45^{**}	0.21^{**}
	(0.50)	(0.08)
Knockout	-0.28	0.06
	(0.40)	(0.06)
Communication density	4.97	0.20
	(3.41)	(0.57)
Communication density squared	5.47^{*}	0.08
	(2.41)	(0.52)
Degree centralization density	0.71	-0.04
	(2.31)	(0.51)
Degree centralization squared	-0.79	0.14
	(1.92)	(0.48)
Constant	6.58^{***}	0.15^{**}
	(0.46)	(0.06)
AIC	1814.59	659.02
BIC	1861.38	705.81
Log Likelihood	-896.30	-318.51
Num. obs.	520	520
Num. groups: name	52	52
Num. groups: round	10	10
Var: name (Intercept)	1.58	0.00
Var: round (Intercept)	0.55	0.00
Var: Residual	1.41	0.19

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 11: Additional controls for the team level. We find similar results for the effect of the node knockout on team records and normalized messages sent with the additional controls.

	Team record	Normalized messages
Diff-in-diff ATE	-0.03	-0.83^{*}
	(0.09)	(0.34)
Time	0.21^{**}	1.45^{***}
	(0.06)	(0.26)
Knockout	0.06	-0.38
	(0.06)	(0.24)
Constant	0.19	2.92
	(0.44)	(1.77)
Communication density	0.45	-2.31
	(0.65)	(2.64)
Communication transitivity	-0.38	7.70^{***}
	(0.43)	(1.74)
Communication diameter	-0.04	-0.11
	(0.10)	(0.40)
Degree centralization	-0.03	1.91
	(0.31)	(1.26)
R^2	0.06	0.18
Adj. R^2	0.04	0.17
Num. obs.	520	520

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

8 Alternative team level controls

In the manuscript, we control for the team communication network density and degree centrality. In this section, we replicate the team level models and include controls for the team communication network density, degree centrality, as well as the communication network transitivity and diameter, as both of these variables may influence team performance or messages sent. Table 11 reports the results. Across both models, we find similar results to the manuscript, with node knockout decreasing the volume of messages sent and having a null effect on team records. Notably, greater communication network transitivity is associated with more messages.

Table 12: Additional controls for the team level. We find similar results for the effect of the node knockout on team records and normalized messages sent with the additional controls.

	Team record	Normalized messages	Team record	Normalized messages
Diff-in-diff ATE	-0.03	-0.83^{*}	-0.04	-1.47^{***}
	(0.09)	(0.34)	(0.08)	(0.21)
Time	0.21^{**}	1.45^{***}	0.18^{**}	0.59^{***}
	(0.06)	(0.26)	(0.07)	(0.17)
Knockout	0.06	-0.38	0.07	-0.15
	(0.06)	(0.24)	(0.06)	(0.15)
Constant	0.19	2.92	-0.08	-3.73^{***}
	(0.44)	(1.77)	(0.15)	(0.38)
Communication density	0.45	-2.31		
	(0.65)	(2.64)		
Communication transitivity	-0.38	7.70^{***}		
	(0.43)	(1.74)		
Communication diameter	-0.04	-0.11		
	(0.10)	(0.40)		
Degree centralization	-0.03	1.91		
	(0.31)	(1.26)		
Communication frequency density			0.56	16.53^{***}
			(0.30)	(0.77)
Communication frequency transitivity			-0.11	0.01
			(0.22)	(0.58)
Communication frequency diameter			0.00	0.39^{***}
			(0.01)	(0.03)
R^2	0.06	0.18	0.06	0.66
Adj. R^2	0.04	0.17	0.05	0.66
Num. obs.	520	520	520	520

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 13: Individual level models with controls for the communication frequency network.

	Degree centrality	Betweenness centrality	Eigenvector centrality
Diff-in-diff ATE	0.15^{*}	0.23^{***}	0.26^{***}
	(0.07)	(0.07)	(0.07)
Time	0.10^{*}	-0.14^{**}	0.03
	(0.04)	(0.04)	(0.04)
Knockout	-0.62^{***}	-0.45^{***}	-0.34^{***}
	(0.05)	(0.05)	(0.05)
Constant	0.66	1.77^{***}	0.20
	(0.65)	(0.40)	(0.54)
Communication density	−0.75	-2.41^{***}	0.56
	(0.98)	(0.61)	(0.81)
Communication transitivity	1.99^{***}	0.51	0.37
	(0.58)	(0.40)	(0.51)
Communication diameter	-0.53^{***}	−0.15	-0.33^{**}
	(0.15)	(0.09)	(0.12)
Degree centralization	−0.44	0.09	−0.07
	(0.39)	(0.28)	(0.35)
AIC	10904.65	11217.47	11240.14
BIC	10967.58	11280.40	11303.07
Log Likelihood	−5442.32	−5598.74	−5610.07
Num. obs.	3995	3995	3995
Num. groups: team	52	52	52
Var: team (Intercept)	0.07	0.01	0.03
Var: Residual	0.87	0.96	0.95

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

9 Alternative individual level controls

In the manuscript, we analyze if players that rewire their network after a node knockout become more integrated into the team communication frequency network. In this section, we replicate our analysis and include controls for the team communication network structure; specifically, communication network density, transitivity, diameter, and degree centralization. Table 13 reports the results. Similar to the main results, the effect of rewiring a network is statistically significant and positive on a player's degree, betweenness, or eigenvector centrality in their team's communication frequency network.

Table 14: The individual level models but treating all teammates on a team that experience a knockout as treated.

	Degree centrality	Betweenness centrality	Eigenvector centrality
Diff-in-diff ATE	$-0.12^{\cdot}$	-0.25^{***}	0.13^{*}
	(0.06)	(0.06)	(0.06)
Time	0.26^{***}	0.03	$0.10^{\cdot}$
	(0.05)	(0.05)	(0.05)
Knockout	−0.07	−0.00	0.02
	(0.05)	(0.05)	(0.05)
Constant	−0.04	0.06	-0.10^{**}
	(0.04)	(0.04)	(0.04)
R^2	0.01	0.01	0.01
Adj. R^2	0.01	0.01	0.01
Num. obs.	3995	3995	3995

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$; $^{\cdot}p < 0.1$

10 Sensitivity analysis

In the main text, we assess how rewiring a players network affects their centrality in their team network after the knockout. However, it is possible that all players on a treated team see increases in their centrality.[1] Here we rerun the difference in difference treatment and consider all participants on a team with a knockout as treated participants to better assess the effect of rewiring after a knockout. Table 14 reports the results. Unlike the players that rewire, the remaining teammates on teams that experience a knockout see decreases in their teams communication frequency network for degree and betweenness centrality.[2] This is consistent with the findings on the volume of messages sent. Further, it suggests that rewiring is more consequential than experiencing a knockout.

[1] The difference in difference model can interpret this effect as an interaction but we replicate it as the main interaction effect here.

[2] The effect is similar for eigenvector centrality but still lower than the estimated effect of people that rewire their network.