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Checkpoint 4: Graph Analytics

Context for this checkpoint: Our group attempts to investigate how socio-demographic features such as race and ethnicity could play a role in the outcomes of police misconduct investigations, rather than focusing on the occurrences of such misconducts. Our project investigates the question: "When a case of police misconduct victimizes groups that are historically marginalized, how unfavorable is its investigation?" We will look at different hypothetical effects such as: (1) "Is an allegation made by a victim of color less likely of being sustained?"; (2) "Do the durations of misconduct investigations vary across victim races?"; and (3) "Do the disciplinary actions differ?"; to test for the presence of significant racial disparities in the outcomes of investigations involving people of color. This checkpoint allows us to move beyond the baselines extracted in Checkpoint #1, the visualizations in Checkpoint #2, and the analysis of settlement outcomes in Checkpoint #3, to analyze how *allegation types* (as in the primary cause of an allegation) affect different segments of the population.

For full context, please refer to file "full_proposal.pdf."

Checkpoint #4 organization and **background information** for interpreting our analyses:

- First, we construct a graph of co-occurring allegation types for the entire CPDB dataset. Nodes represent allegation types (e.g., 'Intoxicated On Duty', 'D.U.I. On Duty') and edges represent allegations committed by the same officer consecutively (e.g., 'Intoxicated On Duty—D.U.I. On Duty'). Edge weights represent the number of occurrences of a pattern for the population under analysis. *Fig. 1 below shows how to construct this network.*
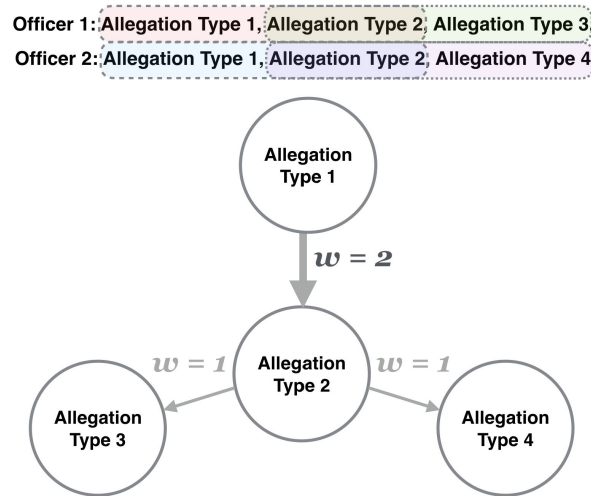

Fig. 1 — A homogeneous network where vertices are allegation types and edges represent co-occurring allegation types in an officer's career. By constructing this network for different populations and studying its topology, we may answer Questions #1 and #2.

- Second, we construct two different versions of this network: one for allegations involving black victims only and one for white victims only. To compare how allegation types co-occur for these different segments of the population, we run a community detection algorithm (Blondel, Guillaume, and Lefebvre, 2009), evaluate the quality of the clustering by its modularity value (Newman, 2006), and analyze the resulting communities to discuss any disparities.

- As detailed in (Newman, 2006) in Eq. 4 and Fig. 3, a modularity value **Q** close to **zero** indicates *poor* clustering results, while a modularity value **Q** *greater than 0.5* indicates *very good* clustering results. Any other values approaching *1.0* indicate *excellent* clustering results.

- Finally, Prof. Rogers **has authorized** the use of NetworkX for this checkpoint. Please refer to our README file for detailed instructions on how to reproduce these results.

Question #1: (a) How allegation types connect (as nodes) in a graph where edges represent allegations committed by the same officer? (b) Can we identify different levels of severity by looking at either components or communities of allegations?

Question #1a Results:

Community	Allegation Types
0	**'Proper Care - Injury / Death', 'Escape', 'Excessive Detention - After Arrest', 'Prisoners Property', 'Illegal Arrest / False Arrest', 'Bonding/Booking/Processing', 'Search - Person / Property', 'Search Of Premise Without Warrant', 'Bonding/Booking/Processing', 'Injury / Death (Under Color Of Law)', 'Improper Search Of Vehicle', 'Telephone / Attorney / Relative Privileges', 'Racial Profiling', 'Arrest, Improper Procedures', 'Improper Detention', 'Failure To Ensure Civil Rights', 'Unlawful / Excessive Investigative Detention (Witness)'**
1	'Excessive Force - Use Of Firearm / Off Duty - Injury', 'Unnecessary Physical Contact / On Duty - No Injury', 'Altercation / Disturbance - Other', 'Auto Theft', 'Solicit / Accept Bribe (Traffic)', 'Extortion', 'Arrestee-During Arrest', 'Damage / Trespassing To Property', 'Abuse Of Authority', 'Reports', 'Excessive Force - Use Of Firearm / On Duty - Injury', 'Conspiracy To Commit A Crime', 'Unnecessary Physical Contact / Off Duty - No Injury', 'Indebtedness To City', 'Domestic Incident - Not Physical', 'Parking Complaints', 'An Act To Circumvent Criminal Prosecution', 'Excessive Force - Use Of Firearm / On Duty - No Injury', 'Absent Without Permission', 'Fail To Enforce Traffic Regulations', 'Traffic Violations (Other Than D.U.I.)', 'Weapon / Ammunition', 'Use Of Official Position', 'Seat Belts', 'Residency', 'Association With Felon', 'Secondary/Special Employment', 'Leaving Assignment (District, Beat, Sector, Court)', 'Recommend Professional Service', 'Misconduct During Issuance Of Citation', 'Slow / No Response', 'Assault / Battery, Etc.', 'Excessive Force / Off Duty - No Injury', 'Excessive Force / On Duty - No Injury', 'Civil Suits - Third Party', 'Solicit / Accept Bribe (Non-Traffic)', 'Theft', 'Compensatory Time', 'Altercation / Disturbance - Neighbor', 'Unnecessary Display Of Weapon / Off Duty', 'Violation (Other Than D.U.I.) - On Duty', 'Excessive Force - Use Of Firearm / Off Duty - No Injury', 'Excessive Force / Off Duty - Injury', 'Judicial Process/Directive - Contempt', 'Drugs / Controlled Substance, Possession Or Sale', 'Knee Strike', 'Preventable Traffic Accident', 'Gang Affiliation', 'Domestic Altercation - Physical Abuse', 'Unnecessary Physical Contact -On Duty', 'U Converted To C.R. (Records Keeping Only, Initial)', 'Arrestee-Lockup/Deletion', 'Excessive Force - Taser - Use Of', 'Criminal Sexual Assault', 'Unnecessary Display Of Weapon / On Duty', 'Other Felony', 'Drivers License - Revoked / Suspended', 'Improper Processing / Reporting / Procedures', 'Misdemeanor Arrest', 'Bribe, Failure To Report', 'Court Attendance Irregularities', 'Police Impersonator (Advocate Section Use Only)', 'No Arrest', 'Stomped / Stepped On', 'Altercation / Disturbance - Traffic', 'Robbery', 'False Testimony In Court', 'Domestic Altercation/Incident - Off Duty', 'Burglary', 'Murder / Manslaughter, Etc.', 'Unfit For Duty', 'Arson', 'Sexual Misconduct', 'Gratuity', 'Shoplifting', 'Traffic', 'Equipment Irregularity'
2	**'Sexual Orientation', 'Miscellaneous', 'Use Of Profanity', 'Improper Search Of Person', 'Impairment .04 Or Greater - On Duty', 'Possession / Drinking Alcohol - On Duty', 'D.U.I. - Off Duty', 'Intoxicated Off Duty', 'First Amendment', 'Racial / Ethnic, Etc.', 'Intoxicated On Duty', 'Impairment .04 Or Greater - Off Duty', 'D.U.I. - On Duty'**
3	'Excessive Force / On Duty - Injury'
4	'Fail To Obtain A Complaint Register Number', 'Positive Drug Screen - Originated From Complaint', 'Positive Drug Screen - Other Physical Exam', 'State Civil Suit', 'Vehicle Licensing - State', 'Political Activity', 'Initiate Proper Action', 'Failure To Ensure - Civil Rights', 'Miscellaneous', 'Just Cause', 'Choked', 'Federal Civil Suit', 'Positive Drug Screen - Promotion Physical', 'Inventory Procedures', 'Conduct An Improper / Inadequate Investigation', 'Dragged', 'Use / Abuse Drugs / Controlled Substance - On Duty', 'Properly Direct Subordinate', 'Firearm Discharge With Hits - Handgun', 'Use / Abuse Drugs / Controlled Substance - Off Duty', 'Closed Hand Strike (Punch)', 'Injury', 'Verbal Abuse', 'Vehicle', 'Shots Fired - No Hits', 'Firearm Discharge With Hits / On Duty', 'Refusal Of Direct Order To Provide Drug Screen Specimen', 'D.U.I., Drugs / Controlled Substance - Off Duty', 'Open Hand Strike (Slap)', 'Coercion - Violence', 'Kicked', 'Forwarded To O.E.C.', 'Positive Drug Screen - Recruit', 'Properly Review / Inspect Subordinate', 'Arrestee-After Arrest,Prior To Lockup', 'Firearm Discharge With Hits / Off Duty', 'Conduct Unbecoming', 'Unjustified Pointing Of Firearm - Handgun', 'Taser (Probe Discharge)', 'Push/Pull/Grab', 'Impact Weapon - Unauthorized (Flashlight, Handcuffs, Etc)', 'Impact Weapon - Authorized (Baton / Asp)', 'Harassment', 'Threats', 'Firearm Discharge No Hits - Handgun', 'Street'
5	**'Inadequate / Failure To Provide Service', 'Neglect Of Duty', 'Misuse Of Department Records', 'Eeo Investigations', 'Insubordination', 'Misuse Of Department Equipment / Supplies', 'Late - Roll Call /**

	Assignment / Court', 'Traffic Pursuit', 'Firearm Discharge With Hits - Rifle / Assault Weapon', 'Lunch / Personal Violations', 'Motor Vehicle Fatality - On Duty', 'Take Down (Thrown To Ground)', 'Firearm Used As An Impact Weapon', 'No Injury', 'D.U.I., Drugs / Controlled Substance - On Duty', 'Drug/Substance Abuse'

Analysis of Question #1a results: As seen in Fig. 2 below, complex networks are hard to analyze using conventional visualizations. And although important, global distributions of topological features such as node degrees and edges types can only inform us of global characteristics of a network. Fig. 3, for instance, shows that edges in this network of co-occurring allegation types follow a power-law distribution, that is, relatively few combinations of allegation types are much more frequent than all the others. This is, however, a common trait of many large networks (Barabási and Albert, 1999).
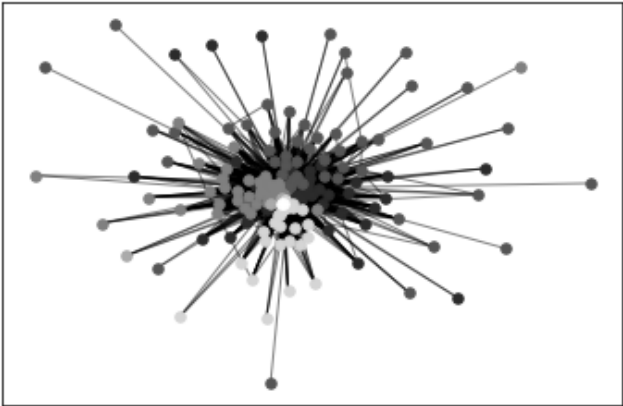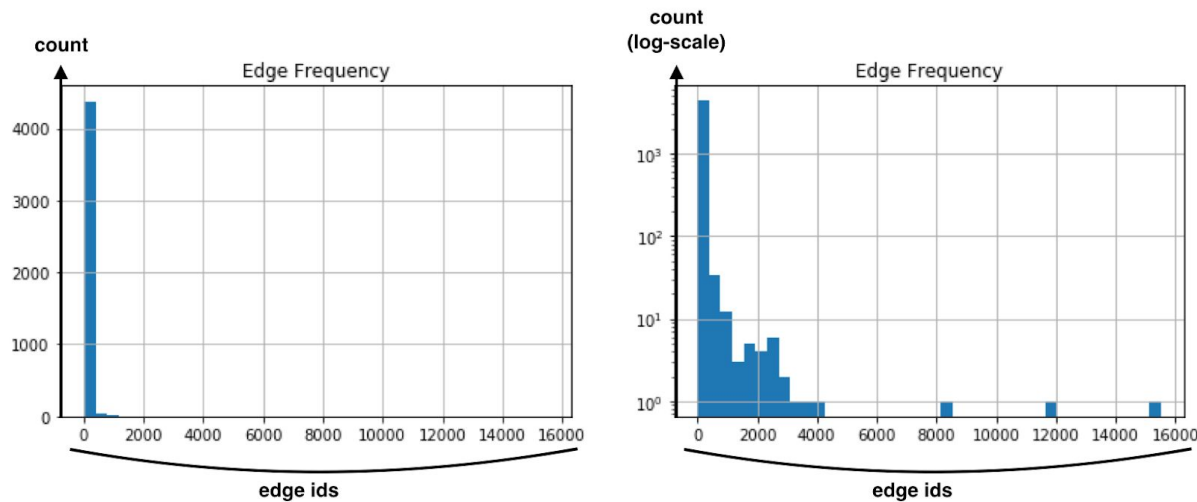

Fig. 2 — A render of our first network.

Fig. 3 — Distribution of edges shows how some patterns are much more prevalent than others, following a power-law. Left: absolute differences in edge counts. Right: differences in log-scale.

For these reasons, we resort to a community detection algorithm to analyze our network (Blondel, Guillaume, and Lefebvre, 2009), and we evaluate its performance by using modularity, which measures the extent to which nodes belonging to a community tends to form connections with each other in comparison with the rest of the network (Newman, 2006). For this question, community detection returned a modularity of **Q = 0.55**, which indicates **very meaningful communities** from a topological perspective (Newman, 2006).

Looking more closely at each community, we were able to highlight in bold our most interesting findings (see table above). Community #0 has "Racial Profiling" and many other violent allegation types tending to co-occur with it, including fatal misconducts and detention of witnesses. Community #2 has patterns of intoxication and DUI ('Possession / Drinking Alcohol - On Duty', 'D.U.I. - Off Duty', 'Intoxicated Off Duty', 'Intoxicated On Duty', 'D.U.I. - On Duty'), and more racially motivated misconduct ('Racial / Ethnic, Etc.'). Community #5 is another one mixing patterns of discrimination ('Eeo Investigations'), intoxication, and a few other violent allegation types. EEO investigations refer to formal complaints of discrimination. Communities #1, #3 and #4 are either too large (catch-all communities) or too small (isolated nodes).

Question #2: If we construct two different networks, one for allegations involving (a) victims of color, and (b) for white victims, do their topologies match? Can we identify disparities in how allegations connect?

Question #2a Results:

Community	Allegation Types
0	'Failure To Ensure - Civil Rights', 'Association With Felon', 'Altercation / Disturbance - Other', 'Altercation / Disturbance - Traffic', 'Domestic Altercation - Physical Abuse', 'Conspiracy To Commit A Crime', 'Sexual Orientation', 'Insubordination', 'Altercation / Disturbance - Neighbor', 'Weapon / Ammunition', 'Injury', 'Possession / Drinking Alcohol - On Duty', 'D.U.I. - Off Duty'
1	**'Racial / Ethnic, Etc.', 'Stomped / Stepped On', 'Taser (Probe Discharge)'**
2	'Excessive Force - Use Of Firearm / Off Duty - No Injury', 'Excessive Force - Taser - Use Of'
3	'Unnecessary Physical Contact / On Duty - No Injury', 'Push/Pull/Grab', 'Properly Direct Subordinate', 'Initiate Proper Action', 'Injury / Death (Under Color Of Law)'
4	'Miscellaneous', 'Unfit For Duty', 'Street', 'Coercion - Violence', 'Use Of Official Position'
5	'Inadequate / Failure To Provide Service', 'Neglect Of Duty', 'Misconduct During Issuance Of Citation', 'Reports', 'Improper Processing / Reporting / Procedures', 'Leaving Assignment (District, Beat, Sector, Court)', 'Slow / No Response', 'Escape', 'Fail To Obtain A Complaint Register Number', 'Impairment .04 Or Greater - Off Duty', 'Parking Complaints', 'Fail To Enforce Traffic Regulations', 'Misuse Of Department Equipment / Supplies', 'Seat Belts', 'Impact Weapon - Authorized (Baton / Asp)', 'No Injury', 'Vehicle'

6	'Proper Care - Injury / Death', 'Search - Person / Property', 'Telephone / Attorney / Relative Privileges', 'Solicit / Accept Bribe (Traffic)', 'Extortion'
7	'Traffic Pursuit', 'Illegal Arrest / False Arrest'
8	'Search Of Premise Without Warrant', 'Absent Without Permission', 'Motor Vehicle Fatality - On Duty'
9	'Other Felony', 'Domestic Incident - Not Physical', 'Harassment'
10	**'Closed Hand Strike (Punch)', 'Shots Fired - No Hits'**
11	**'Unnecessary Physical Contact / Off Duty - No Injury', 'Conduct An Improper / Inadequate Investigation'**
12	'Improper Search Of Vehicle', 'Court Attendance Irregularities'
13	'Damage / Trespassing To Property', 'Civil Suits - Third Party'
14	'Unlawful / Excessive Investigative Detention (Witness)', 'Improper Search Of Person', 'Gang Affiliation', 'Bonding/Booking/Processing', 'Use / Abuse Drugs / Controlled Substance - Off Duty', 'Drugs / Controlled Substance, Possession Or Sale', 'Impact Weapon - Unauthorized (Flashlight, Handcuffs, Etc)'
15	**'Excessive Force - Use Of Firearm / Off Duty - Injury', 'Theft', 'Eeo Investigations', 'Kicked'**
16	'Use Of Profanity', 'Solicit / Accept Bribe (Non-Traffic)', 'Intoxicated Off Duty', 'Preventable Traffic Accident'
17	'Excessive Force / On Duty - No Injury', 'Firearm Discharge With Hits / Off Duty', 'Miscellaneous'
18	'Excessive Force - Use Of Firearm / On Duty - No Injury', 'Criminal Sexual Assault'
19	'Misuse Of Department Records', 'Traffic Violations (Other Than D.U.I.)', 'Sexual Misconduct', 'Just Cause'
20	**'Excessive Detention - After Arrest', 'Prisoners Property', 'Dragged', 'Firearm Discharge With Hits / On Duty', 'Failure To Ensure Civil Rights', 'Assault / Battery, Etc.'**
21	**'Unnecessary Display Of Weapon / Off Duty', 'D.U.I., Drugs / Controlled Substance - Off Duty', 'Choked', 'Intoxicated On Duty'**
22	'Arrest, Improper Procedures', 'D.U.I. - On Duty', 'First Amendment'
23	'U Converted To C.R. (Records Keeping Only, Initial)', 'Excessive Force - Use Of Firearm / On Duty - Injury'
24	'Excessive Force / On Duty - Injury'
25	**'Misdemeanor Arrest', 'Abuse Of Authority', 'Excessive Force / Off Duty - No Injury', 'Excessive Force / Off Duty - Injury', 'Police Impersonator (Advocate Section Use Only)'**
26	'Inventory Procedures', 'State Civil Suit', 'Political Activity'
27	'Open Hand Strike (Slap)'
28	'An Act To Circumvent Criminal Prosecution'
29	'Arson'

30	'Unjustified Pointing Of Firearm - Handgun'
31	**'Racial Profiling', 'Firearm Discharge With Hits - Handgun'**
32	'Unnecessary Display Of Weapon / On Duty'
33	'Take Down (Thrown To Ground)'
34	'Violation (Other Than D.U.I.) - On Duty'
35	'Improper Detention'
36	'Federal Civil Suit'

Analysis of Question #2a Results: Focusing on victims of color, community detection returned a modularity of **Q = 0.67**, which indicates **extraordinarily meaningful communities** from a topological perspective (Newman, 2006).

Again, we highlighted in bold our most interesting findings (see table above). Community #0 has "Racial Profiling" and many other violent allegation types tending to co-occur with it, including fatal misconducts and detention of witnesses. Communities #1 ('Racial / Ethnic, Etc.', 'Stomped / Stepped On', 'Taser (Probe Discharge)') and #31 ('Racial Profiling', 'Firearm Discharge With Hits - Handgun') are particularly worrisome, linking violent behavior to racism. Communities #10, #11, #20, #21 and #25 show more exceptionally violent behavior tending to co-occur in allegations involving victims of color. And Community #15 is another one mixing patterns of discrimination ('Eeo Investigations') and a few other violent allegation types. EEO investigations refer to formal complaints of discrimination. Finally, as expected in large scale networks, many other communities are too small to analyze.

Question #2b Results:

Community	Allegation Types
0	**'Excessive Force / On Duty - No Injury', 'Verbal Abuse'**
1	**'Domestic Incident - Not Physical', 'Racial Profiling', 'D.U.I. - On Duty', 'Closed Hand Strike (Punch)'**
2	**'Gang Affiliation', 'Illegal Arrest / False Arrest', 'Use / Abuse Drugs / Controlled Substance - Off Duty', 'Take Down (Thrown To Ground)'**
3	'Prisoners Property', 'Altercation / Disturbance - Neighbor', 'Misuse Of Department Records', 'Firearm Used As An Impact Weapon'
4	'Eeo Investigations', 'Telephone / Attorney / Relative Privileges', 'Injury', 'Use Of Official Position', 'Court Attendance Irregularities'

5	'Improper Search Of Vehicle', 'Threats', 'Seat Belts'
6	**'Sexual Orientation', 'Unnecessary Physical Contact / Off Duty - No Injury'**
7	**'Unnecessary Display Of Weapon / Off Duty', 'Misconduct During Issuance Of Citation', 'Use Of Profanity'**
8	'Excessive Force / On Duty - Injury'
9	'Damage / Trespassing To Property', 'Firearm Discharge With Hits - Handgun', 'Conduct An Improper / Inadequate Investigation', 'Inventory Procedures', 'Assault / Battery, Etc.'
10	'Fail To Obtain A Complaint Register Number', 'Altercation / Disturbance - Traffic', 'Push/Pull/Grab'
11	**'Racial / Ethnic, Etc.', 'Harassment'**
12	'Excessive Force / Off Duty - No Injury'
13	**'Neglect Of Duty', 'Criminal Sexual Assault', 'Failure To Ensure - Civil Rights', 'Violation (Other Than D.U.I.) - On Duty', 'Other Felony'**
14	**'Excessive Force / Off Duty - Injury', 'Sexual Misconduct', 'Burglary', 'Initiate Proper Action'**
15	'Unnecessary Display Of Weapon / On Duty', 'Intoxicated Off Duty'
16	'Association With Felon', 'Altercation / Disturbance - Other'
17	'Miscellaneous', 'Arrest, Improper Procedures', 'U Converted To C.R. (Records Keeping Only, Initial)', 'Intoxicated On Duty'
18	'Domestic Altercation - Physical Abuse', 'Secondary/Special Employment', 'Excessive Force - Use Of Firearm / On Duty - Injury', 'Judicial Process/Directive - Contempt'
19	'Conspiracy To Commit A Crime', 'Unnecessary Physical Contact / On Duty - No Injury'
20	'Misuse Of Department Equipment / Supplies', 'Proper Care - Injury / Death'
21	'Insubordination', 'Indebtedness To City', 'No Injury'
22	'Inadequate / Failure To Provide Service', 'Slow / No Response', 'Absent Without Permission', 'Leaving Assignment (District, Beat, Sector, Court)', 'Fail To Enforce Traffic Regulations'
23	'Excessive Force - Use Of Firearm / Off Duty - No Injury'
24	'Search Of Premise Without Warrant', 'D.U.I. - Off Duty', 'Escape'
25	**'Excessive Force - Use Of Firearm / On Duty - No Injury', 'Theft', 'Use / Abuse Drugs / Controlled Substance - On Duty', 'Drugs / Controlled Substance, Possession Or Sale'**
26	'Reports', 'Abuse Of Authority', 'Possession / Drinking Alcohol - On Duty'
27	'Improper Search Of Person', 'Search - Person / Property', 'Extortion'
28	'Improper Processing / Reporting / Procedures', 'Weapon / Ammunition', 'Firearm Discharge No Hits - Handgun', 'Excessive Force - Use Of Firearm / Off Duty - Injury', 'Properly Direct Subordinate'

29	'Excessive Force - Taser - Use Of'
30	'Recommend Professional Service'
31	'Parking Complaints'
32	'First Amendment'
33	'Solicit / Accept Bribe (Non-Traffic)'
34	'Knee Strike'
35	'Choked'
36	'Firearm Discharge With Hits - Rifle / Assault Weapon'
37	'Improper Detention'
38	'Civil Suits - Third Party'

Analysis of Question #2b Results: Focusing on white victims, community detection returned a modularity of **Q = 0.74**, which indicates **extraordinarily meaningful communities** from a topological perspective (Newman, 2006). It's worth noting that we have a larger quantity of small communities compared to victims of color, reflecting a smaller set of misconduct patterns involving white victims.

Again, we highlighted in bold our most interesting findings (see table above). While we do find patterns of intoxication (Communities #2 and #25), Communities #0 ('Excessive Force / On Duty - No Injury', 'Verbal Abuse') and #7 ('Unnecessary Display Of Weapon / Off Duty', 'Misconduct During Issuance Of Citation', 'Use Of Profanity') illustrate how misconduct patterns tend to be less violent when compared to our previous analysis. Moreover, we can see patterns of misconduct due to sexual orientation (Community #6) or sexual offense (Communities #13 and #14), and still other patterns of racial and ethnic discrimination (Communities #1 and #11).

It's also worth noting that we have a larger range of allegation types involving people of color compared to white victims (125 vs 108). Similarly, we have many more combinations of allegation types (1292 vs 725).

Overall Findings: Question #1 analyzed the network of co-occurring allegation types for the entire CPDB dataset, and in Question #2 we explored this representation for more specific populations — black victims and white victims, respectively. For all these three settings, we found strong evidence that the community detection algorithm is successful, as measured by a gold-standard in the field (modularity). We looked into each community and found different patterns of violence strongly associated with race, ethnicity, and sexuality, which not only

confirms our initial hypothesis but potentially extend it towards other segments of the population. Looking at our results for victims of color, in particular, we found that violent behavior is much more prevalent among this population and is manifested in a number of different patterns. We think that our analysis shows that race and ethnicity may play a role in police misconduct and that use of force could be racially discriminatory. We also think it has provided predictable reasons for why people of color are less likely to trust the police. Finally, on a more technical level, our results show that networks of co-occurring allegation types follow a power-law distribution, like many others in the literature of complex networks (Barbási and Albert, 1999).
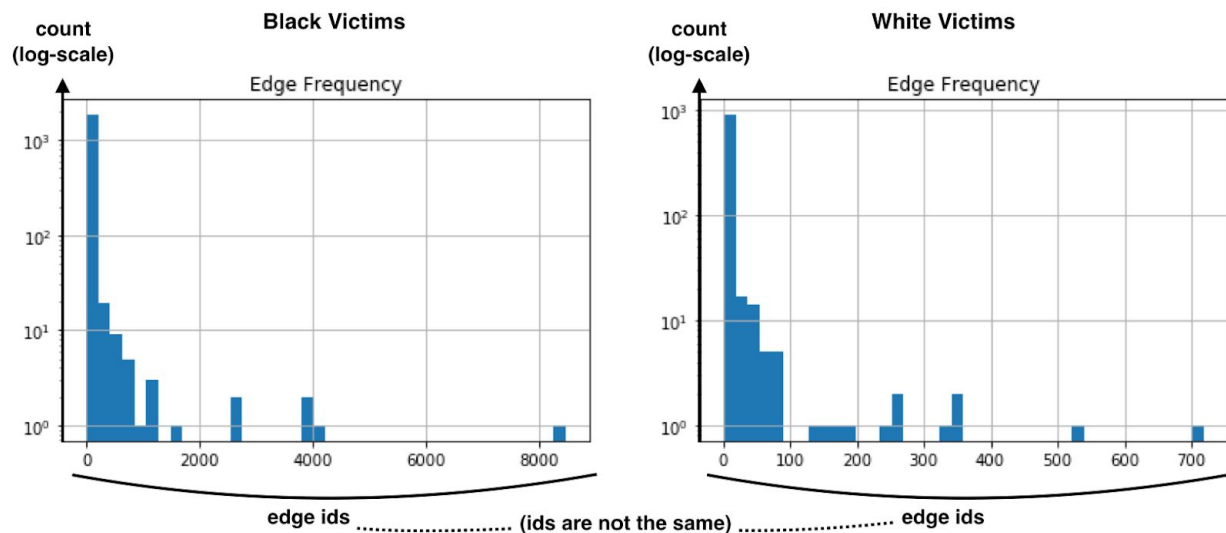

Fig. 4 — Distributions of edges show how the power-law behavior is a general phenomenon. Left: black victims only. Right: white victims only.

References

Blondel, V. D., Guillaume, J. L., Lambiotte, R., & Lefebvre, E. (2008). **Fast Unfolding of Communities in Large Networks.** *Journal of Statistical Mechanics: Theory and Experiment*, *2008*(10), P10008.

Newman, M. E. (2006). **Modularity and Community Structure in Networks.** *Proceedings of the National Academy of Sciences*, 103(23), 8577-8582.

Barabási, A. L., & Albert, R. (1999). **Emergence of Scaling in Random Networks.** *Science*, 286(5439), 509-512.