The function and parameters for simulating the infection follows very closely to the original simulations presented by the Stanford flu paper. The infection starts off from a single random node in the network and there will be no other infections introduced into the network. All members in the network start off as susceptible expect for the members who were vaccinated. The chance of a susceptible member becoming exposed from an infected member is 1 – (0.997)^w where w is the weight of the edge between the two members. If the susceptible member becomes exposed they incubate for two time steps before turning into the infected state. Once in the infected state the individual remains infected for two time steps where they can infect susceptible members before turning into recovered. The time steps for the model are split into day and night and infected members can only infect others during the day. Individuals who were once infected and recovered are not turned back into the susceptible state to be re-infected. The vaccinations are given out before the initial infection of the network and the vaccines are assumed to be 100% effective so none of the vaccinated individuals can become infected. There are no additional vaccinations given after the initial infection. The final number of infected is recorded and used to gauge the effectiveness of different vaccination strategies.

The first method of vaccination tested was random vaccinations. For this method random members of the network are selected and given vaccines. This method requires zero knowledge of the network and would be the easiest to implement in real life. The fact that zero knowledge is needed to act on this method makes it the ideal case to use for comparing the performance of the other algorithms. If the other algorithms which require some network knowledge have comparable results to random vaccinations then the time and effort needed to collect the network knowledge is unnecessary. No vaccinations cannot be used as a baseline due to the fact that even at small vaccination percentages almost every strategy succeeds^1. One of the difficulties of identifying effective vaccination algorithms for this project was that random vaccinations work well at stopping infections. From figure \_\_\_\_ we see how the random vaccination graph.

Another strategy for vaccination what was tested was max degree. The strategy works by randomly selecting a group of individuals from the network and vaccinating those with the highest degrees. The reason for choosing this vaccination method is because it seemed intuitive to vaccinate the members of the network that are connected to the most people as they are the most likely to be infected and have a better chance to infect others. The first part of implementing this algorithm is determining how to select the group of individuals from the network. The most obvious strategy is to randomly select people from the network and take the highest degrees. The other strategy that was attempted is selecting several nodes and taking their immediate neighbors and another looking at the neighbors of the neighbors. The reasoning for these strategies is that the infection can only pass through neighbors and vaccinating the neighbors with the highest degrees should protect that section of the network. Going back to the first strategy for max degree we realize a fundamental problem that continually comes up in this project. That problem is determining a threshold for the number of vaccines to give out to a given group size. For example in the max degree situation if we have a group of people ordered by their degree what is the cutoff degree where only those above the cutoff get vaccines. Setting a rate such as the top 10% seems reasonable until the realization that to vaccinate 10% of the school would require knowing the degree of every node in the network. Setting the rate close to a 100% of the selected nodes would be similar to the random algorithm which defeats the purpose. The threshold problem is one where an ideal balance between network knowledge and effectiveness has to be found.

Another vaccination strategy that was tested was max strength which is a variation of max degree. The strength of a node is the sum total of all of its edge weights. In an unweighted graph the strength and degree value are equivalent since the weights of all the edges are equal to 1. However since the network is weighted and the infection spreads with probability calculated from edge weights there may be improvements for a strategy that uses strength.

The final vaccination strategy that was studied was betweenness centrality. The betweenness centrality algorithm was another strategy that was difficult to determine where a subgroup should be selected from. The betweenness centrality score is determined by the number of shortest paths that pass through a node meaning that it requires a connected network to work properly. The original implementation of the algorithm was done by selecting a random node and selecting all nodes within a distance of two edges. The problem with selecting the network in that manner is that it would heavily bias the centrality scores as the starting node will have a much higher score than it normally would. The nodes that were two edges away from the starting node would also be biased because they will not have all their connections and will have a lower score than they would in the original network. However when the comparison of centrality scores was made there ended up being very little bias. The lack of bias resulted in a closer look at the network which revealed the network’s tiny diameter. The two edge sampling was covering a large portion of the network. The small diameter of the network allowed us to implement a different method for calculating betweenness. Random nodes were chosen from the network and the subgraph of those nodes was generated. The network is heavily connected so if we chose a large enough group of random nodes the will be connected together in one component. Closeness centrality was considered but the original paper showed no difference between random vaccination and closeness centrality. The reason closeness centrality likely failed is due to the fact that the network is a small world network so the differences in the centrality scores for closeness were tiny.

There are several flaws to this project in addition to the flaws present in the original paper. One major flaw is that getting the partial knowledge required for some of the algorithms would be difficult to implement in real life. The edge weights and degrees are based on a 3 meter proximity rather than direct face to face interaction so any target would not be able to accurately tell you their degree or edge weights correctly. They could only be determined by having the subject and the rest of the school wear the sensors at which point the entire network could be constructed. Another major flaw is that the spread of infection in a network and the effectiveness of vaccination strategies are heavily dependent on the structure of the network. This means that strategies designed for this network cannot be simply translated into general use and can only be effectively implemented for the studied network.

Before looking at the vaccination strategies the properties of the network have to be understood to better understand the results of those strategies. First we look at the degree and strength distributions. Next we look at the diameter of the network and the result is surprisingly low at only 3.