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Closing the gap: A novel metric of change in performance

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Abstract

BACKGROUND—Interventions to improve performance of global programs in the HIV cascade of care are widespread and increasing the focus of implementation science. At present, however, there is no clear consensus on how to conceptualize their improvement at the program level. The commonly used measures of association, based on ratios of probabilities (or odds), have well-known defects in public health applications. They yield large effect sizes even when the absolute effects, and therefore the public health impact, are small. On the other hand, risk differences create problems because settings with higher baseline values are penalized. We aim to examine ways of quantifying improvement in each health center of a cluster-randomized trial in Uganda to accelerate antiretroviral therapy initiation among HIV-infected adults.

METHODS—We formalize the concept of the 'improvement index,' defined as the fraction of gaps closed as a metric of improvement, and suggest that it has unique features and strengths when compared to risk ratios and risk differences.

RESULTS—Overall agreement between the different indices was not high, especially among health centers that were among the top 5 or 10. However, all ranking showed broad similarities at the far ends of the spectrum. On scatter plots, there was a positive linear relationship between the metrics, and the Bland Altman (B-A) plots were in agreement.

CONCLUSION—The improvement index can be used as an alternative measure of association in implementation science interventions. It can be useful for public health purposes as it demonstrates how much can be covered from the baseline.

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AUTHORS' CONTRIBUTIONS

RK and EG carried out the conception and design, acquisition of data, analysis and interpretation of data and also drafting the manuscript. JW and DVG also carried out analysis of the data. FCS reviewed the manuscript for important intellectual content, participated in the design of the study, and helped to draft the manuscript. GA, LK, JN, MRK, and DH reviewed the manuscript for important intellectual content and helped draft the manuscript. All authors read and approved the final manuscript.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

Keywords

Antiretroviral therapy; improvement index; agreement; intervention; HIV

BACKGROUND

Interventions to improve performance of global programs in the HIV cascade of care are increasingly widespread and a focus of implementation science as well as routine program improvement activities (Hickey et al., 2017). For example, results-based financing represents a broad family of strategies that offer monetary rewards to facilities to make improvements or meet targets (Basinga et al., 2011; Gomez Atun, 2012). These rewards are often used by the facility for the facility or, in some cases, as take-home pay for health care workers (Bassett, Wilson, Taaffe, Freedberg, 2015; Rajkotia et al., 2017). Many other approaches, which are not based on financial incentives, also seek to use improvements in performance as a metric of success. Reputational incentives – through the use of awards – are increasingly common (Amanyire, Semitala, Namusobya, Katuramu, Kampiire, Wallenta, Charlebois, Camlin, Kahn, Chang, 2016). Quality improvement strategies are also increasingly asked to demonstrate effects, and therefore looking at change over time or across facilities is increasingly called for (Berwick, 2004, 2008). Even traditional quality assurance schemas are based on whether or not a set of activities reaches prespecified benchmarks (Perriëns, 2004). Finally, scientific evaluation of change in practice or improvement is increasingly a focus of implementation science (Kitson et al., 2008). In these studies, it is often necessary to understand both the pooled results across all study sites as well as the extent of change in subgroups or even individual sites.

Many measures of association used to indicate improvement suffer from limitations. The most traditional measures of association, odds ratios (OR), risk ratios (RR) or relative risks, are based on ratios of probabilities or odds (Sterne, 1988; Tripepi, Jager, Dekker, Wanner, Zoccali, 2007), and each has some shortcomings in public health applications. Ratio measures of association can be large even when the absolute effects, and therefore the public health impact, is small. In general, risk differences (RD) have been favored to understand public health impact; absolute risk differences tell us the number needed to treat to create change (King, Harper, Young, 2012). Yet risk differences also have limitations: facilities or settings that have higher starting points are penalized (because there isn't much room for improvement) when compared to facilities that start at a low level of performance. A 'difference' measure of association could be seen, therefore, as having more to do with the starting point than how much effort or change is achieved. Still other metrics are based on a clinic making a certain absolute threshold as a sign of success, irrespective of how much change was required to achieve that threshold (e.g., UNAIDS 90-90-90 targets). If a facility is already near a threshold, they may expend relatively little to make the benchmark, and therefore miss obtainable additional improvements.

In this paper, we examine the site level results of a stepped-wedge cluster-randomized trial in Uganda that involved 20 separate health facilities to accelerate antiretroviral (ART) initiation among HIV-infected adults (Amanyire, Semitala, Namusobya, Katuramu, Kampiire, Wallenta, Charlebois, Camlin, Kahn, Chang, 2016). Given the notable heterogeneity across facilities in the level of the outcome (rapid ART initiation) before the introduction of the intervention, we use this opportunity to examine different approaches to the quantification of improvement in each clinic. We formalize the concept of the 'improvement index' (II), defined as the fraction of gaps closed as a metric of improvement and suggest that it has unique features and strengths when compared to more traditional measures of association such as OR, RR, and even RD. We seek to advance the conceptualization of improvement through articulating the relative strengths, weaknesses and unique contributions of different types of metrics to improve the HIV cascade of care.

METHODS

Setting

The data used in this study are from the START-ART study in Uganda (ClinicalTrials.gov, number NCT01810289), whose design, methods, and results have been described elsewhere (Amanyire, Semitala, Namusobya, Katuramu, Kampiire, Wallenta, Charlebois, Camlin, Kahn, Chang, 2016). Briefly, the START-ART study was a cluster-randomized stepped-wedge trial conducted between April 2013 and July 2015 with the aim of increasing the rate of ART initiation among HIV-infected treatment-eligible patients. It was conducted within 20 public health facilities that offer ART for HIV, based in Kampala and Mbarara districts. The health facilities were randomized into groups of five every six months, and the study included all treatment-naïve HIV-infected adults clinically eligible for ART who met criteria for ART under the Ugandan national guidelines during the study period. The START-ART study was approved by institutional review boards of the University of California and by ethics boards at the Makerere University in Kampala and the Uganda National Council for Science and Technology.

The START-ART intervention was based on the PRECEDE model which suggests that 'predisposing, enabling and reinforcing' factors are needed to create behavior change among health care workers (Green, 2005). Predisposing factors are knowledge or information that inclines or influences a person to a particular behavior, enabling factors are materials or skills that facilitate the desired behavior, and re-enforcing factors are the anticipated rewards to consequences of behavior. For a predisposing factor, we used an opinion leader-led interactive training that conveyed recent scientific evidence regarding the benefits of rapid initiation of ART from trials (e.g., ACTG 5164) (Geng et al., 2011; Zolopa et al., 2009) and the risks of delayed ART initiation (e.g., loss to follow-up, AIDS progression in those with advanced immunosuppression) to frontline HIV care providers. Secondly, for an enabling factor, we introduced a point-of-care PIMA™ CD4 test machine to each clinic. The PIMA delivered an absolute count of T-helper cells from either a finger stick or venous whole-blood sample within 20 minutes and allowed determination of treatment eligibility on the same day as presentation (Coetzee et al., 2010; Glencross, Coetzee, Lawrie, Stevens, Osih, 2010). Finally, as the re-enforcing factor to motivate sites, the study provided bi-annual feedback that involved presentation of the clinic ART initiation rates as compared to other clinics. The feedback meetings were held quarterly with health facility leaders ('in-charges') as well as all staff at the clinics.

Examining the measures of effect in the before- and after-intervention studies

In the before-intervention (unexposed) and after-intervention (exposed) studies, we examined the effectiveness of the intervention among the targeted population by determining changes over time between the groups by calculating the OR, RR, and RD. For the OR, we examined the ratio of odds the outcome of interest before the intervention and after the intervention roll-out (Cunningham Card, 2014; Tu et al., 2014). For the RR, we examined the risk of an outcome among the population before the intervention and after the intervention; and for the RD, we calculated the difference in proportions between the participants with outcome of interest in the intervention group and before the intervention (Amanyire, Semitala, Namusobya, Katuramu, Kampiire, Wallenta, Charlebois, Camlin, Kahn, Chang, et al., 2016).

Population and sample

As in the parent START-ART trial, we analyzed all the HIV-infected ART-eligible patients within the period of the START-ART intervention in this paper. At the time of the study initiation, the CD4 threshold for ART initiation was 350 cells/ul, which was increased to 500/ul during the study period. In this analysis, we included all eligible persons and focused on facility-level estimates to understand variability in site-level response to the intervention, and by extension, explored different metrics of change.

Measures

Information collected in this study included health facility characteristics, including the level of the facility, wave of randomization, number of patients eligible at the facility was before the intervention, number of patients eligible while the facility was in the intervention period, and number of patients initiated on ART during the study period. These were obtained from the patients' ART charts at each of the specific health facilities.

Statistical analysis

The primary outcome of the START-ART study was ART initiation within 14 days after the first date of eligibility for ART during the study period. This was treated as a binary variable where patients were deemed either to have started ART or not to have started ART by 14 days. Patients with less than 14 days of observation time before crossover to intervention or end of study database closure were not included in the analysis of the primary outcome. In this analysis, we examined the primary outcome at each facility by comparing the proportion of people who were eligible who initiated ART before and after the intervention first using traditional measures of association. The period of observation time started in April 2013, prior to any intervention, and ended in February 2015 (Amanyire, Semitala, Namusobya, Katuramu, Kampiire, Wallenta, Charlebois, Camlin, Kahn, Chang, et al., 2016).

First, we calculated the RR of each facility, defined as the proportion of patients who initiated ART within 14 days in the facility before the intervention to the proportion of patients who initiated ART within 14 days after the intervention in the same facility (P_1/P_0). Second, we calculated a traditional RD of each facility through subtracting the fraction of patients starting ART rapidly in the facility before the intervention within 14 days from the fraction of patients starting rapidly in the same after the intervention within the same period

(P_1-P_0). In addition to these two measures of association, we calculated the 'II,' in each facility, which was defined as the percentage of the gap closed after the introduction of the intervention within the same facility, or [(P_1-P_0)/(1-P_0)]. In all cases, P_0 is the proportion of patients having the primary outcome before the intervention, and P_1 is the proportion of patients having the primary outcome after the intervention within the same facility.

To evaluate differences between each metric of improvement (e.g., RR, RD or II), we used scatter plots and Pearson's correlation coefficient to examine correlation between each of the metrics of improvement. We used Bland Altman (B-A) plots (Bland_Altman, 1986) of facility ranking according to each of these approaches to evaluate agreement between the approaches. The mean of these differences across all the 20 health facilities was computed, along with 95% limits of agreement. The width of the limits of agreement indicated the variability of the difference between II and RR or RD. We also used medians and interquartile ranges (IQR) to describe the overall changes in the different metrics across all facilities. Analysis was performed using STATA version 12.0. Health facility characteristics were described in terms of percentages, as appropriate.

RESULTS

Data were obtained from 20 health facilities ranging from large referral hospitals to rural health centers. The study population comprised of 12,024 patients who were eligible for ART initiation during the study period, of whom 7,277 (60.5%) enrolled during periods in which the facilities were implementing the intervention arm (Table 1, Figure 1).

A total of 10,182 (84.7%) people started ART. All the health facilities experienced a change in ART initiation within 14 days during the intervention. Seven health facilities had their ART initiation improve 30% - 45%, while five health facilities had their ART initiation improve 45% - 60% (Table 2).

The median RR for change across all facilities was 2.3 (IQR 1.4) with a range from 1.2 to 4.0. The median RD across all facilities was 39.5 (IQR 24.1) with a range from 9.0 to 66.0. The median OR across all facilities was 2.3 (IQR 1.1) with a range from 1.2 to 4.1. The median II across all facilities was 56.3% (IQR 30.9%) and ranged from 14.0% to 81.9% (Figure 2).

There were broad similarities in rankings between the metrics at the low end of the spectrum (those with smaller improvements in ART initiation), but these diverged at higher ends (facilities with greater improvements) (Table 3). At the high end of the spectrum, while health 'facility 12' was the top-ranked health facility irrespective of whether OR, RR, RD or II was used, there were differences in the rankings in the rest of the top five, depending on which metric was used. The second-ranked health facility using RR was 'facility 16': using OR it was ranked 7th, using RD it was 8th, and when using II, it was in the middle of the pack at 11th. The third-ranked health facility using RR was 'facility 4,' but this facility ranked 12th when using OR and RD, and dropped to 14th when using II. The fourth-ranked health facility using the RR metric was 'facility 19,' which in this case was ranked much higher at second place using OR and RD and but was fourth using II.

At the lower end of the spectrum, the differences in the ways that each metric ranked the last five facilities were smaller and less pronounced than at the top end. ‘Facility 14’was ranked last at 20th using the RR metric and at 19th using OR, RD and II. ‘Facility 6’ was ranked 19th using RR but 20th using OR, RD, II. The 18th ranked health facility in all the four metrics was ‘facility 7.’

Differences between rankings derived from each of the four metrics were most pronounced in the middle-ranked health facilities. For example, ‘facility 13’ was ranked 11th using RR, 4th using OR, 5th using RD and 3rd using II. ‘Facility 18’ was ranked 12th using RR and 9th using OR, RD and II (Table 3, Figure 1).

The B-A plots were used to capture the concept of agreement and showed that the median difference between the II rank and the RD rank was zero, but that the 95% limits of agreement were positive or negative 4, suggesting a wide spread of eight places in ranking in a field of 20 candidate facilities (Figure 2) could be expected. The extent to which II was in agreement with the RR rank and RD rank is represented in B-A plots (Figures 3 and 4).

DISCUSSION

In this paper, we examine a number of ways of conceptualizing improvement at a facility level that can be applied to different interventions to improve the HIV cascade of care. These metrics yielded relatively small overall differences, but these differences could be meaningful in certain contexts. In particular, when used to create ranks, the facilities that clustered near the top exhibited relatively poor agreement on the rankings. These findings suggest that different measures do not yield the same ranking, and therefore the selection of different measures is important and must match the purpose.

The data from the current study also suggest that the probability of change on an absolute scale and the effect of an intervention at a particular site represent different ideas and therefore require different conceptualizations. In the public health setting, often the desire is to improve outcomes for the greatest absolute number of patients. When this is the case, the RD remains the best metric of the extent to which people are affected by improvement of a facility. For example, if a facility improves from 10% to 50%, in truth the number of individuals who benefit is larger than an increase of 80% to 90%. On the other hand, when we need to know what effect an intervention had on practice (rather than patient outcomes), II is a more helpful metric. II gives each facility a chance to improve that is not benchmarked by baseline measures like the RD is. Indeed, even though it is not a ratio measure of association where the measure can grow rapidly, the RD is bounded by 1, and therefore it penalizes high-functioning clinics. Although this may be appropriate for public health practice, for an intervention that seeks to make change, a smaller magnitude of change may reflect a tremendous amount of organizational or process changes – effects that we seek to capture in a scientific or research setting. We therefore believe that II is a better metric for scientific research seeking to capture the effects of practice change interventions.

This analysis has certain limitations. The stepped-wedge design of the START-ART study did not allow all the facilities equal exposure, as some facilities were in the intervention condition longer than others. This could have affected the degree of improvement measured, as it was observed that the worst-performing health facilities were in the last clusters of the wedged design, and the best-performing clinics were in the first two clusters, although this was not consistent.

CONCLUSION

We have tested a metric of assessing outcomes in implementation interventions, the II, that reports the percentage of the gap closed after the introduction of an intervention in a facility, which we believe is useful for public health program planning purposes.

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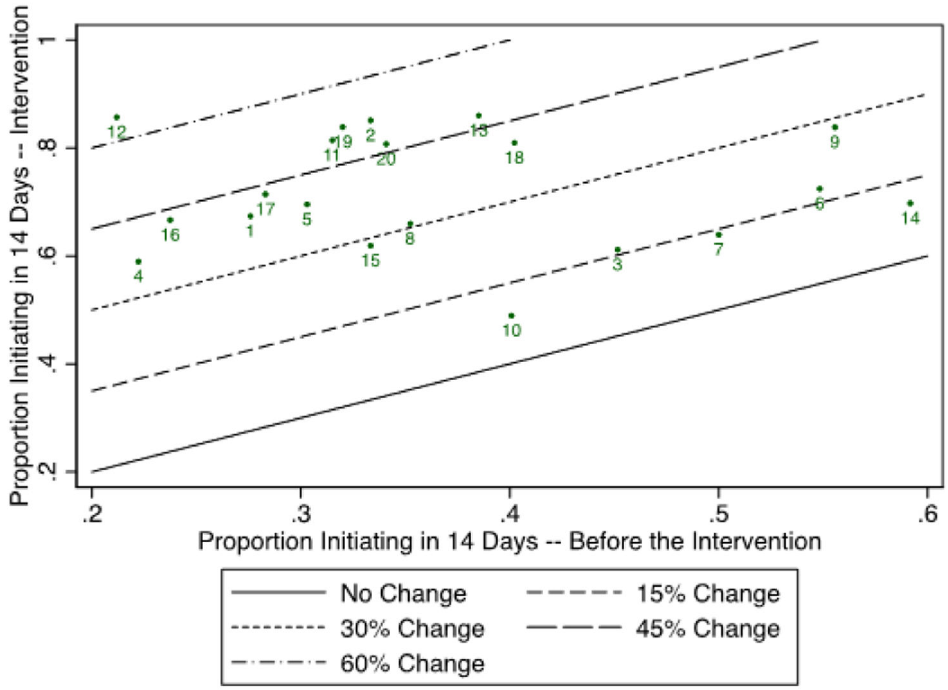

Figure 1.

Proportion of patients initiating ART within 14 days in intervention against proportion of those initiating within the same time period before the intervention.

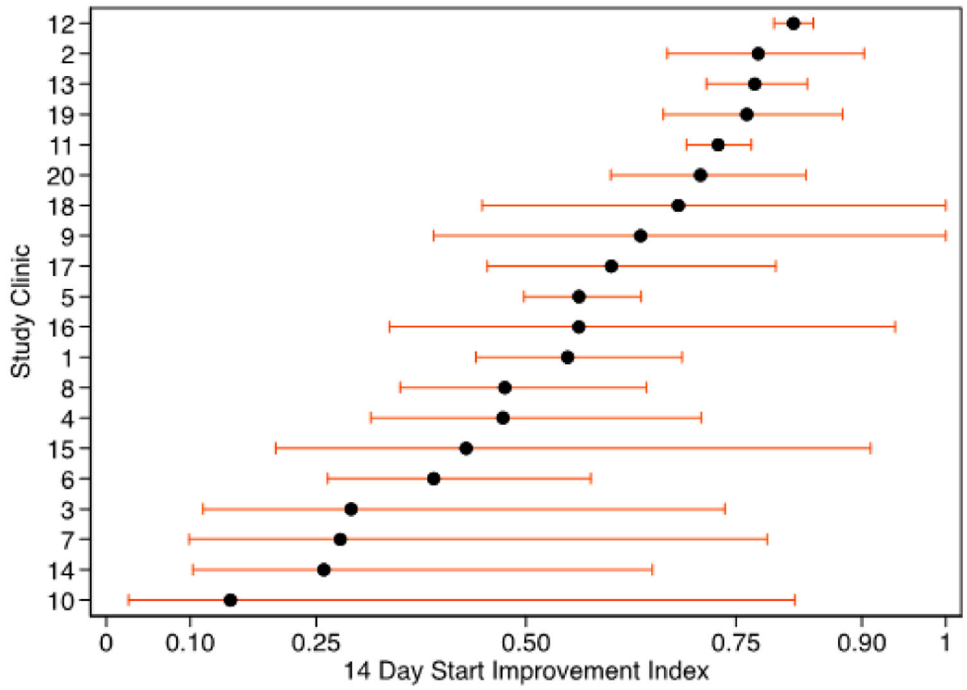

Figure 2.

Percent improvement in proportion of patients initiating ART by 14 days after eligibility for ART ('Improvement Index') by health facility

Figure 3.

Scatter plots of rankings between different metrics (RR, RD, and II)

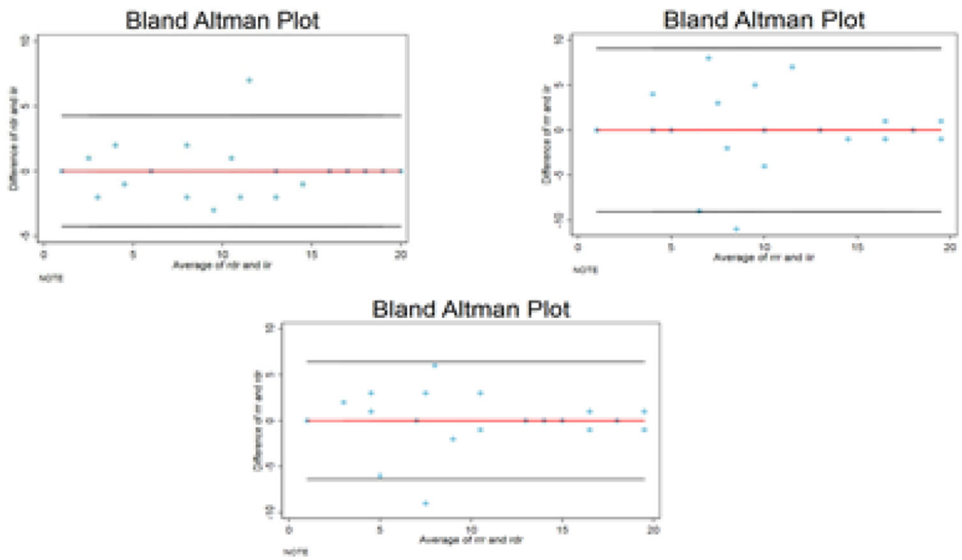

Figure 4.

Bland Altman plots showing the rankings of the three metrics risk difference risk ratios and improvement index

Table 1.

Characteristics of 20 health facilities in Kampala and Mbarara districts of Uganda during the START-ART study period

Health facility	Level	Waves	Total # of patients	Total # of patients on ARV (%)
1	New	2	228	205 (89.9)
2	Small	2	143	121 (84.1)
3	Medium	1	172	143 (83.1)
4	Small	1	97	83 (85.6)
5	Large	3	954	842 (88.3)
6	Medium	3	627	536 (85.5)
7	Small	3	142	128 (90.1)
8	New	2	236	197 (83.5)
9	New	1	111	102 (91.9)
10	Medium	4	308	266 (86.4)
11	Large	3	1,956	1,551 (79.3)
12	Large	1	2,156	1,773 (82.2)
13	Large	4	3,550	3,079 (86.7)
14	Medium	3	313	279 (89.1)
15	Medium	4	109	97 (89.0)
16	New	4	161	134 (83.2)
17	Small	2	120	105 (87.5)
18	New	4	114	99 (86.8)
19	Small	1	183	164 (89.6)
20	New	3	344	278 (80.8)
Total			12,024	10,182 (84.7)

Table 2.

Number and proportions of patients initiated on ART in 20 health facilities in Kampala and Mbarara districts of Uganda during the study period

	Before intervention			After intervention		
Health facility	**No. of patients**	**Proportion on ART**	**Proportion on ART within 14 days**	**No. of patients**	**Proportion on ART**	**Proportion on ART within 14 days**
1	87	0.79	0.28	141	0.91	0.67
2	49	0.49	0.33	94	0.91	0.85
3	33	0.46	0.45	139	0.71	0.61
4	19	0.53	0.22	78	0.71	0.59
5	560	0.77	0.30	394	0.89	0.70
6	431	0.81	0.55	196	0.90	0.72
7	81	0.88	0.50	61	0.90	0.64
8	92	0.72	0.35	144	0.81	0.66
9	12	0.43	0.56	99	0.92	0.84
10	261	0.72	0.40	47	0.85	0.49
11	1,052	0.63	0.32	907	0.91	0.81
12	555	0.33	0.21	1,601	0.89	0.86
13	3,207	0.72	0.39	343	0.95	0.86
14	191	0.87	0.59	119	0.92	0.7
15	88	0.72	0.33	21	0.86	0.62
16	143	0.70	0.24	18	0.78	0.67
17	57	0.74	0.28	63	0.87	0.71
18	93	0.76	0.40	21	0.95	0.71
19	28	0.52	0.32	155	0.90	0.84
20	235	0.65	0.34	109	0.90	0.81
Total	4,747			7,277		

Table 3.

Odds Ratios, risk ratios, risk differences, and improvement index of ART initiation 14 days after first eligibility for ART, within 20

Health facility	OR	OR Rank	RR	RR Rank	RD	RD Rank	II (%)	II Rank	Lower limit	Upper limit
1	5.42	10	2.44	8	0.4	10	54.95	12	44.02	68.58
2	11.05	3	2.56	6	0.52	3	77.66	2	66.81	90.27
3	1.91	17	1.35	16	0.16	17	29.16	17	11.54	73.68
4	4.97	12	2.66	3	0.37	12	47.25	14	31.51	70.86
5	5.30	11	2.29	10	0.39	11	56.31	10	49.77	63.71
6	2.17	16	1.32	17	0.18	16	39.00	16	26.36	57.72
7	1.77	18	1.28	18	0.14	18	27.87	18	9.87	78.70
8	3.59	14	1.88	13	0.31	13	47.47	13	35.02	64.33
9	4.15	13	1.51	15	0.28	15	63.64	8	38.99	100.0
10	1.43	20	1.22	19	0.09	20	14.78	20	2.67	82.00
11	9.52	5	2.58	5	0.5	4	72.87	5	69.10	76.84
12	22.19	1	4.04	1	0.66	1	81.85	1	79.56	84.22
13	9.76	4	2.23	11	0.48	5	77.24	3	71.47	83.48
14	1.59	19	1.18	20	0.11	19	25.92	19	10.33	65.02
15	3.26	15	1.86	14	0.29	14	42.86	15	20.17	91.04
16	6.45	7	2.81	2	0.43	8	56.29	11	33.72	93.97
17	6.41	8	2.52	7	0.43	7	60.15	9	45.37	79.74
18	6.34	9	2.01	12	0.41	9	68.14	7	44.78	100.0
19	11.06	2	2.62	4	0.52	2	76.28	4	66.35	87.79
20	8.06	6	2.37	9	0.47	6	70.77	6	60.10	83.34