The resilience of regional African HIV/AIDS research networks to the withdrawal of international authors in the subfield of Public Administration and Governance: lessons for funders and collaborators

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1. Background

As part of a broader project examining the relationships between academics, agencies and organisations responsible for developing and implementing HIV/AIDS policy, this study mapped the co-authorship research network in African public administration and governance. Of interest was (a) the extent to which African authors are embedded into the global community of scholars; (b) the extent to which the networks of relationships between African scholars across Africa are mediated by relationships with authors from developed countries and (c) the differences between the relatively well funded network subset related to HIV (the HIV network) and the less well funded network in general public administration and governance research (the general network). If the African scholarship networks are bridged or mediated by international authors, then the removal of international authors from the network as international funding priorities shift will have disproportionate effects on the stability of the African academic network and the ability of African scholars to maintain productive regional collaborations.

2. The importance of regional networks for HIV research in public administration and governance

Regional networks are important for the ongoing success of HIV research in public administration and governance for several reasons. First, and most generally, social networks are a form of social capital essential to research quality and quantity (Nieves and Osorio 2012). Researchers and research teams are less productive and less successful in isolation than they are when connected in to communities of practice. Second, there are important lessons from regional neighbours' responses to HIV/AIDS that can only be learned through strong and consistent regional collaboration, and regional research networks are important building blocks of health systems capacity (Zumla et al. 2010). Third, African research is less likely to be published (Briggs and Weathers 2016) and, when it is, African authors are less able to access paywalled literature (Tennant et al. 2016) making regional collaboration networks particularly important for the incubation, generation, and transmission of local knowledge and research. African countries, and particularly sub-Saharan countries, will need to find

local solutions to address HIV/AIDS into the future long after international funding priorities have moved on.

3. Funding, collaboration and ownership in African research

There tends to be little intra-regional research collaboration in the Southern African Development Community (SADC) and even less collaboration between different regions in Africa (Boshoff 2009; Quayle and Greer 2014; Mêgnigbêto 2013; Pouris and Ho 2013). Developing African research capacity, especially the local and regional resources and connections that will be required to thrive independent of international input and resources is crucial for African research capacity-building (Whitworth 2008). Ideally the benefits of international research funding and collaboration need to translate into structures that allow local and regional collaboration networks to 'take up the slack' in response to future changes in international inputs, for example when international interests or funding priorities change (Nchinda 2009). The extent to which local research networks are independent and resilient to international contingencies is a very important aspect of research capacity building.

Health research in Africa is primarily funded by foreign donors (AVAC 2015). After the 2008 global financial crisis, there was widespread concern that HIV research funding would be cut. While these fears were not immediately realized, after decades of sustained growth, global HIV/AIDS related research funding levelled-out between 2008 and 2014 (Katz et al. 2014) and declined by 13% from 2014 to 2015 (Kates et al. 2016). The funding environment is uncertain and it is not clear whether research networks forged in times of plenty will be resilient when less funding is available.

Persistent North-South research collaboration is particularly dependent on international funding (Zumla et al. 2010), and international funding does not necessarily result in well-connected local networks (Paina et al. 2013). Where international funding and collaborative North-South research projects fail to build local and regional capacity there is a real risk that research networks in the South will not be resilient to the withdrawal of partners when funding priorities change in the North. However, where funding and collaboration have resulted in enhanced regional research

capacity, local networks should be better connected and more resilient to withdrawal (Paina et al. 2013).

4. Health-checking research networks with bibliometrics

Academic co-authorship networks are the visible manifestation of academic collaborations, revealing structural features of intellectual capital and knowledge generation systems. Co-authorship analysis identifies networks of authors where links represent shared authorship of a paper and is a practical way to identify research collaborations via their outputs (Lundberg et al. 2006; Glänzel and Schubert 2005) and to map the connections between researchers in a field (Katz and Martin 1997). This reveals the connectivity of the collaboration network at local, regional and international levels, which is an important factor in the resilience of African research networks (Sall 2010). Once the network is identified via bibliometric co-authorship, it can be characterised in terms of its connectivity and structure.

As part of a broader research project investigating policy and public administration in Africa, the present study aimed to assess the vulnerability of research networks supported by international HIV/AIDS funding in the subfield of Policy and Public Administration. This subfield was focussed on as the study was part of an Irish Aid funded project specifically investigating HIV/AIDS in relation to public policy and administration.

Specifically, the study compares the field of African Policy and Public Administration *in general* (that has developed organically with relatively low levels of funding) with the subfield specifically related to HIV (that has developed rapidly with high levels of targeted funding and international involvement). By comparing the resilience of these two networks to the withdrawal of non-African partners we loosely assess the extent to which focussed international funding has contributed to regionally sustainable research capacity. In particular we aimed to explore (1) how well embedded African authors are in the global community of scholars; (2) the extent to which regional networks of African scholars are mediated by authors from other continents and (3) differences in network resilience between the network resulting from highly targeted HIV/AIDS funding (the HIV

network) and the less well funded work in general public administration and governance research (the general network).

5. METHOD

Bibliographic data was accessed from the Thompson Web of Knowledge (WoK) and processed with the Sci2 tool (Sci2 Team 2017) and a custom script to extract and geomap the co-authorship network of international scholarship on African governance and public policy (1) related to Africa generally and (2) related to HIV/AIDS and Africa (see online supplement for search strategy). Network analysis was undertaken with igraph in R (Csardi & Nepusz, 2006). Papers with more than 10 authors were excluded due to the increasingly uneven author contributions as team size increases. Authors on larger collaborative papers have high degree from single publications; and the larger the number of authors on a single paper, the less likely it is that any individual author made a substantive contribution. This sampling decision excluded 98 of 4,000 sampled papers from the HIV network and 358 of 32,255 from the general network.

Authors were considered African if any of their affiliations on any of their publications were located in Africa. Location was determined from authors' affiliation addresses. Authors with multiple publications had often moved over time, so our algorithm used only the most recent affiliation address to code location. This method unavoidably includes some authors not resident in Africa but publishing with African affiliations. Of special interest were collaborations between African and international scholars and between African scholars from different African countries (for brevity, hereafter *foreign Africans*).

There are some caveats to these methods: first, the WoK database is not consistent in using first names or initials, making it impossible to know whether "Name, Surname" and "Initial, Surname" are different people. In this study all author names were converted to surname/initial format which would have resulted in small but unknown number of authors with the same surname/initial combinations being treated as single entities, but reducing the very common problem of accidentally splitting individual authors into multiple entities. The first-initial scheme has been shown to

outperform surname-only and multiple-initial schemes, and correctly identifies approximately 97% of authors in test cases (Milojevic, 2013).

We explored several manual and semi-automated disambiguation schemes, but several features of the present data made them impractical: (1) African authors tend to be poorly documented on institutional or personal websites; (2) many authors in the dataset published with multiple and inconsistently reported affiliations; (3) African authors tended to have fewer publications, less frequent publications and less regular publication schedules than international samples, (4) they frequently worked in multiple distinct research groups, often with some years between projects; and (5) co-authorship networks were highly fragmented. For these reasons, we were unable to use disambiguation schemes relying on author metadata or network-based disambiguation schemes (Ferreira, Gonçalves, & Laender, 2012; Hussain & Asghar, 2017).

While disambiguation is a serious problem, there are several reasons why it is less so for the present analysis. First, it is most problematic for Asian names (Kim & Diesner, 2015), which were not common in this sample. Second, disambiguation is most problematic for analyses that compare individual-level rather than system- level outcomes (Amancio, Oliveira, & F. Costa, 2014; Erman & Todorovski, 2015). Third, in this analysis the main conclusions are drawn from comparing networks sampled with the same disambiguation strategy; thus errors are likely to be relatively evenly distributed across the networks being compared and are unlikely to drive observed differences between them.

To assess the potential impact of disambiguation errors on the results we ran a parallel analysis that excluded the authors most likely to be subject to disambiguation errors in each network (Milojevic, 2013). These were identified as those where multiple author records had the same name but were from different institutions in the same year. This excluded 183 authors from the HIV sample (2.55%) and 1,964 authors from the general sample (6.23%). Despite the higher proportion of author records excluded from the general network in the parallel analysis, the results are similar and the key findings are still supported. The parallel analysis is reported in Online Supplement 2.

6. RESULTS

Descriptives for the networks are presented in Table 1. The general network (31,539 authors, 77,138 links, link density = .015%) was larger, but less densely connected, than the HIV-specific network (7,165 authors, 18,452 links, link density = .07%).

Table 1: descriptives

	General	General (African only)	HIV	HIV (African only)
Authors	31539	10479	7165	2614
Edges	77138	16359	18452	4755
Density	0.000155	0.000298	0.000719	0.001392
Diameter	28	31	23	20
Normalized betweenness[1]	0.000073	0.000071	0.000193	0.000160
Normalized closeness[2]	0.000056	0.000106	0.000190	0.000416

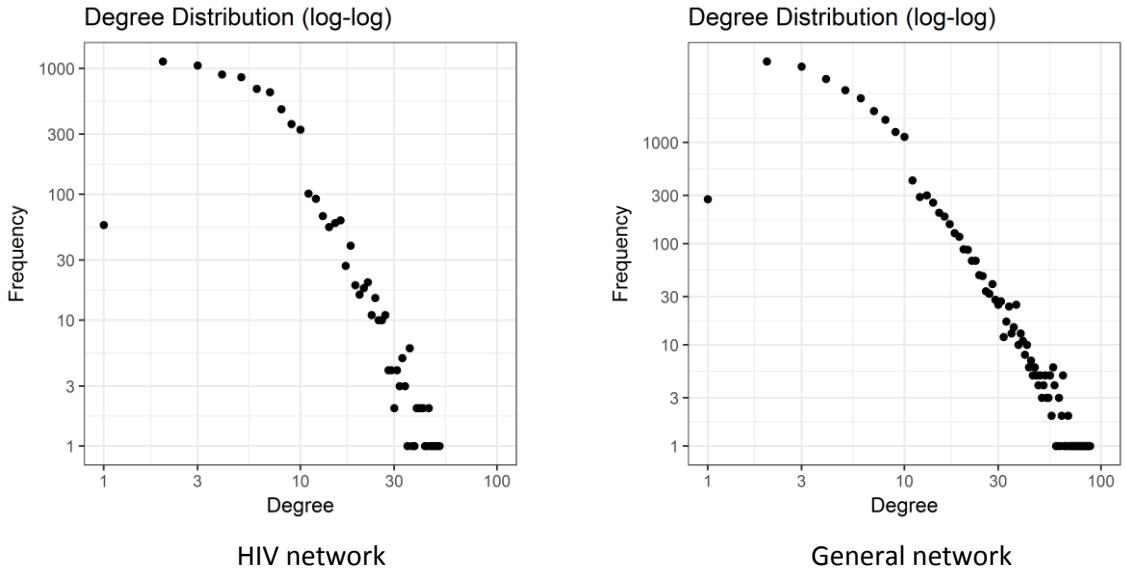

Figure 1: Degree distribution

The degree distribution of both networks is displayed in Figure 1. The discontinuity at degree 10 results from the sampling decision to only include papers with 10 or fewer authors. Authors on large collaborative papers can have relatively high degree with small numbers of publications; and the sampling-related discontinuity in degree distribution for both networks shows that this is an important

[1] To better allow comparisons between graphs of different size, betweenness is normalized "according to Bnorm=2*B/(n*n-3*n+2) where Bnorm is the normalized [betweenness], B the raw betweenness, and n is the number of vertices in the graph" (http://igraph.org/r/doc/betweenness.html)

[2] To better allow comparisons between graphs of different size closeness is normalized "by multiplying the raw closeness by n-1, where n is the number of vertices in the graph" (http://igraph.org/r/doc/closeness.html).

feature in co-authorship networks in Africa; and particularly so in the relatively well-funded HIV network.

African scholars were generally well positioned in both networks, with strong lines of collaboration evident between African countries and developed countries (Figure 2). In the HIV network African authors had a slightly higher (mean = 1.37) number of publications than non-Africans (mean = 1.32, Welch's t = 2.3033, df = 5087.6, p = 0.021). This difference was in the same direction but not significant in the general network. In both networks non-African authors were more likely to be listed as the corresponding author (HIV: Mann-Whitney-Wilcoxon W = 5,710,000, $p <$ 0.001; general: Mann-Whitney-Wilcoxon W = 95,053,000).

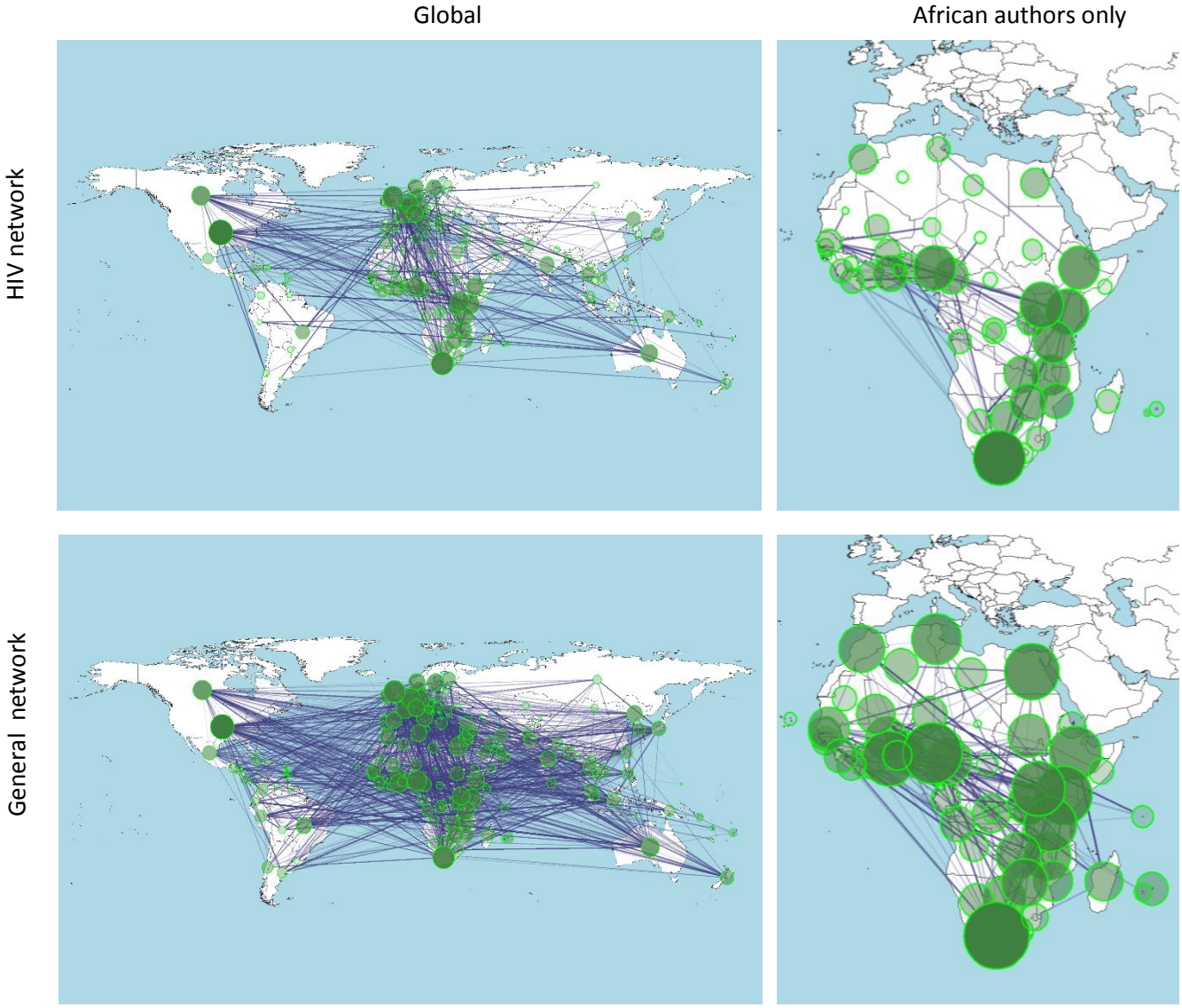

Figure 2: Geo-mapped co-authorship networks

In both networks non-African authors tended to publish with smaller groups of authors (HIV: Mann-Whitney-Wilcoxon W = 6,589,900, $p < .001$; General: Mann-Whitney U = 104,980,000, $p < .001$). In the the HIV network African authors (mean = .61) were marginally more likely to have higher author precedence (measured as author position/number of authors) than non-Africans (mean = .62, Mann-Whitney-Wilcoxon W = 5,782,600, $p = 0.048$) but there was no difference in precedence in the general network.

In both networks about a third of authors were directly linked with a foreign African collaborator. In the general network a further 35.3% could reach a foreign African via one to eight hops. In the HIV network a further 37.1% of authors could reach a foreign African author via one to nine hops. No network links to foreign African collaborators at all were available to 33.1% of the general network and to 40.4% of the HIV network.

In both networks, where a path was possible, the distance (the number of hops needed to traverse through the network) between each author and their nearest foreign African neighbour was significantly higher for African than for non-African authors (HIV: Mann-Whitney-Wilcoxon W = 2,937,300, $p < .001$; General: Mann-Whitney-Wilcoxon W = 50,695,000, $p < .001$). In other words, African authors are more distant to foreign Africans than international authors are, showing that international authors are acting as bridges between Africans in different African countries in both networks. In the general network African authors were significantly less likely to have any route at all to foreign African authors than to non-Africans ($\chi^2 = 24.410$, df = 1, $p < .001$, $\varphi = 0.029$), but this was reversed in the HIV network where African authors were more likely to be connected to noncompatriot Africans in the network than non-Africans were ($\chi^2 = 8.036$, df = 1, $p = .004$, $\varphi = 0.034$).

The giant component of a network is the largest connected cluster and usually identifies the core researchers in a field. All authors in a giant component can reach all others via a finite number of hops. In both networks Africans were significantly more likely than non-African to be included in the giant component (GC; the largest connected cluster) and this was more pronounced in the HIV

network (χ^2 = 100.03, df = 1, p <.001, φ = .118) than the general network (χ^2 = 20.592, df = 1, p <.001, φ = .026).

In both networks Africans included in the giant component were relatively well integrated within it. In the general network the giant component consisted of 17,951authors of whom 6,014 (33.5%) were African. In the HIV network the giant component consisted of 3,212 authors of whom 1,375 (42.8%) were African. However, in both giant components African authors were more distant to non-compatriot Africans than non-African authors (HIV: Mann-Whitney-Wilcoxon W = 1,711,300, p < .001; General: Mann-Whitney-Wilcoxon W = 36,946,000, p < .001). However, in both networks African authors had higher *higher* standardized closeness than non-African authors, and this was more pronounced in the HIV network (HIV: $Mean_{African}$ = .136, $SD_{African}$ = .02, $Mean_{Non\text{-}African}$ = .127, $SD_{Non\text{-}African}$ = .02, t(3086.8) = 13.564, p < .001; General: $Mean_{African}$ = .127, $SD_{African}$ = .02, $Mean_{Non\text{-}African}$ = .125, $SD_{Non\text{-}African}$ = .02, t(12225) = 5.342, p < .001).

When international authors and their links were removed both giant components became more fragmented and disconnected. The 6,014 African authors in the general giant component separated into 1214 independent connected components representing 51countries, with only 12% of these including more than one country. A large proportion included authors only from South Africa (17.6%). However, a substantial giant component remained containing 2,939 authors from 41 African countries (74.5% of all 55 African states).

For the HIV network the 1,375 African authors remaining from the giant component once international authors were removed fragmented into 189 independent connected components representing only 34 of the 55 African countries (61.8%). A larger proportion of components included more than one country than the general network (16.4%) but only five network fragments contained authors from more than three African countries each. The largest linked 21 African countries with 48.1% (N = 661) of African authors from the original giant component.

A stress-test was performed following (Albert, Jeong, & Barabási, 2000). For each network we dropped a proportion of nodes at random, incrementing the proportion dropped from 1% to 90% and replicating each step 100 times (Figure 3). Given differences in size and connectivity of these networks, Jeong et al's method of comparing increases in diameter was not diagnostic; so we

compared relative diameter, calculated as the ratio of the diameter to total paths (Deccio, Matthew Smith, Wan, Clement, & Snell, 2003) for both the complete network and for the largest remaining component. We also plotted the number of components and the relative size of the largest component (i.e. the ratio of largest component size to total network size).

Increasing diameter represents decreasing overall connectivity. In the general network, relative diameter increased slowly and smoothly as nodes were dropped. The relative diameter of the general network only reached the higher starting point of the HIV network once approximately 80% of nodes were dropped. This pattern was even more striking when considering relative diameter of the largest remaining component, which rose relatively rapidly and unpredictably for the HIV network and not much at all for the general network.

The general network fragmented more rapidly than the HIV network, partially because a much larger proportion of authors were included in the giant component to start with. The fragmentation of the general network only matched that of the HIV network once approximately 30% of nodes were dropped. The size of the largest component decreased relatively linearly for the general network. The HIV network, in comparison showed a sharper drop-off, suggesting a network more sensitive to fragmentation.

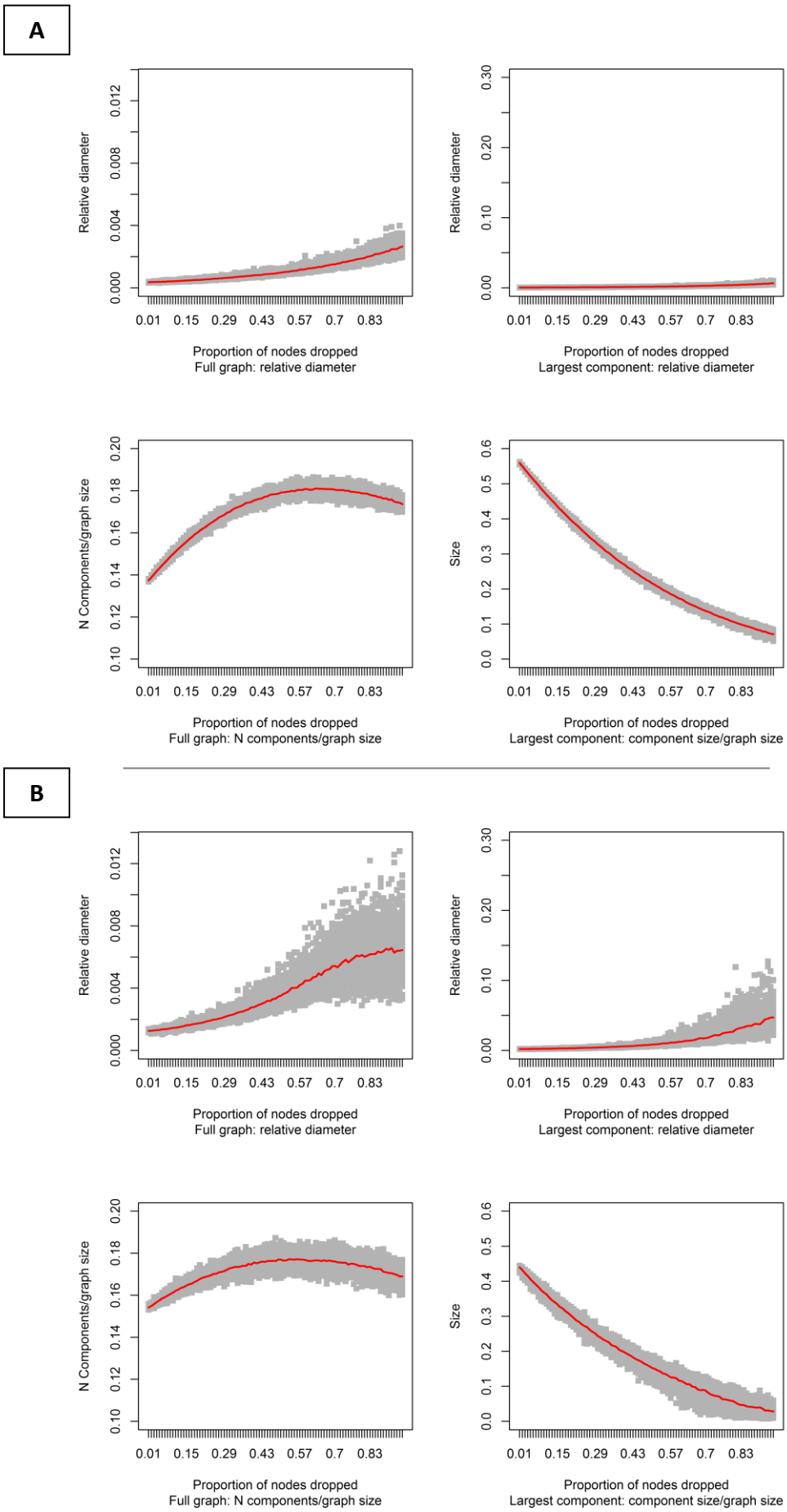

Figure 3: Stresstest (A) for general network and (B) HIV network

7. DISCUSSION AND CONCLUSION

These results tell a story of two networks. The general network, relatively unaffected by high profile international funding, has a large proportion of African scholars working in disconnected silos with little access to other scholars in the network, African or otherwise. However, there is a large giant component in which African authors are well represented and have relatively high status in terms of number of publications and authorship position. In this network African authors and countries are well represented in the giant component, and these regional connections are relatively resilient to the withdrawal of non-African authors.

In comparison the African collaboration network in the field of HIV/AIDS in public administration and governance is also thriving, and African authors are active and well positioned in the network. In the HIV network African authors are more central, have higher mean publications. This advantage in closeness may be partly due to African partners being in relatively high international demand *because* the African research network is smaller and less connected than those of non-African counterparts (Mêgnigbêto 2013) and funding agencies requiring African representation on grants. Africans' higher average closeness in the HIV network corresponded with other advantages, including higher authorship precedence and slightly more publications overall (in this Africa-focussed sampling frame at least). In both networks international authors were more likely to be listed as corresponding author, possibly signifying a difference in power.

These African collaboration networks are fragile because inter-African links are highly mediated by international authors who have bridging functions in the network; and this is more pronounced in the HIV than the general network. Stress-testing showed that the general network is more resilient to the dropout of authors; and that the giant component in the HIV network is particularly vulnerable to the withdrawal of international authors, which would leave African authors in a large number of small and regionally disconnected local collaboration networks. The largest of these would include only 21 of the 55 African countries. This collaboration network is therefore relying heavily on international authors to 'bridge' African authors from different African countries, much as flights between many African countries are connected via ex-colonial hubs in Europe (Button

et al. 2015; Njoya 2016). Even within the African-only subnetworks, regional connections are highly dependent on a small number of research-active countries, particularly Sourh Africa.

These results show that the regional African academic network in Public Administration and Governance related to HIV is potentially highly sensitive to shifts in funding priorities that may cause international authors currently acting as network bridges to reduce their African collaborations. While international funding has clearly generated a productive and connected network of African and international researchers in the field, it has resulted in a network structure in which regional African collaboration structures are heavily reliant on continued international collaboration; and this is very likely to depend on continued international funding.

Differences in vulnerability between the general and HIV networks may be related to patterns of growth, with the former developing slowly and organically, and the latter developing rapidly via targeted funding. This is an open question for further research that can be explored using dynamic network analysis of similar data. However, funders can future-proof emergent networks against future vulnerability if they (a) recognize the ways in which the networks they have created are vulnerable and (b) include network resilience measures in grant awards, for example, insisting that research groups include regional African collaborations. Considering the regional connectivity of research networks in grant outcomes is particularly important in developing-world contexts as failing to do so maintains the core-periphery relationship between developed and developing world researchers (Glänzel, & Schubert, 2005).

We recommend that international funders should carefully consider the sustainability of regional African collaboration in funding models. Specifically, grants should encourage multi-regional African collaboration to develop African collaboration networks resilient to the withdrawal of international researchers; thus providing a firmer platform for regional African research collaboration into the future. Since network connectivity is partly dependent on scale, with giant components emerging at predictable moments dependent on network size and connectivity (Strogatz 2008), funders should consider both the critical mass of African authors in the research networks they are supporting and the regional interconnectedness of those networks. Stress-testing networks using

bibliometric analysis is a low-cost and effective method for assessing regional capacity building efforts that can easily be replicated with little effort.

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