

1 Mapping Regional Cooperation of State Actors for Health Research Systems 2 in Africa: A Social Network Analysis 3

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18 Abstract 19

20 Regional bodies can potentially play an important role in improving health research in Africa. This study
21 analyses the network of African state-based regional organisations for health research and assesses their
22 potential relationship with national health research performance metrics.
23

24 After cataloguing organisations and their membership, we conducted a social network analysis to determine
25 key network attributes of national governments' connections via regional organisations supporting
26 functions of health research systems. This data was used to test the hypothesis that state actors with more
27 connections to other actors via regional organisations would have higher levels of health research
28 performance across indicators.
29

30 With 21 unique regional organisations, the African continent is densely networked around health research
31 systems issues. In general, the regional network for health research is inclusive. No single actor serves as a
32 nexus. However, when statistics are grouped by African Union regions, influential poles emerge, with the
33 most predominate spheres of influence in East and West Africa. Further, when connectivity data was
34 analysed against national health research performance, there were no statistically significant relationships
35 between increased connectivity and higher performance of key health research metrics.
36

37 The inclusive and dense network dynamics of African regional organisations for health research
38 strengthening present key opportunities for knowledge diffusion and cooperation to improve research
39 capacity on the continent. Further reflection is needed on appropriate and meaningful ways to assess the
40 role of regionalism and evaluate the influence of regional organisations in strengthening health research
41 systems in Africa.
42

43 **Keywords:** Africa, health cooperation, health research, regional organisations, regional cooperation,
44 regionalism, social network analysis
45
46

47 **Introduction**

48 Regional organisations are increasingly involved in health policy matters within their broader
49 sectoral integration mandates, (1) including in Africa (2,3). Public health emergencies such as the 2014
50 Ebola outbreak and current COVID-19 pandemic have highlighted the unique roles that regional
51 organisations in Africa can play in coordination, resource pooling, or scientific leadership when they have
52 institutional capacity for these (4–6). The involvement of regional organisations in epidemics and disease
53 control has been identified as a way to strengthen regional cooperation in health within Africa through
54 diplomacy, with such organisations seen to be operating at the interface of global health institutions and
55 national governments — seeking to represent and act on their shared interests, align strategies, promote a
56 unified position, or mobilise partnerships (3,7,8).

57

58 Although COVID-19 analysis has reminded us of the role of regional organisations in Africa to
59 support member states’ preparedness and response, some regional organisations, like the West African
60 Health Organisation, have reported building on their experience from previous epidemics and their work to
61 strengthen health research capacity across member states (9,10). To advance a regional approach to research
62 capacity strengthening, cross-border collaboration between government agencies, research institutions and
63 researchers has arisen from these emergencies, as in the instance of the establishment of the West Africa
64 Consortium for Clinical Research on Epidemic Pathogens formed since the Ebola virus disease outbreak of
65 2014-2015. Health research capacity within national health research systems is fundamental to produce and
66 use knowledge that informs national preparedness and response to health emergencies (11–13).

67

68 But the urgency and significance of an agenda to strengthen research capacity in African countries
69 is not novel. The landmark report of the Commission on Health Research and Development in 1990 (14)
70 argued that local research systems and capacity are essential to reduce health inequities and advance
71 knowledge in and for low- and lower-middle income countries. International organisations and funding
72 agencies have promoted health research capacity strengthening through partnerships and initiatives, which

73 have produced and supported numerous collaborations and mechanisms to advance this agenda. For
74 example, the European and Developing Countries Clinical Trials Partnership (15), the Sub-Saharan African
75 Network for TB/HIV Research Excellence (SANTHE) (16), the African Institutions Initiative (17), the
76 African Doctoral Dissertation Research Fellowship (ADDRF) program (18), and the African Network for
77 Drugs and Diagnostics Innovation (ANDI) (19), the WHO Special Programme for Research and Training
78 in Tropical Diseases (TDR) (20,21), and the Consortium for Advanced Research Training in Africa
79 (CARTA) (22,23) – to name a few - have demonstrated research capacity improvements at various levels.
80 The core message across this body of knowledge, including from our research on nine national health
81 research systems in Africa (24), is that leadership and ownership of partnerships by African research
82 leaders, institutions, or governments are vital for sustainable, independent research capacity. While
83 partnerships, collaborative strategies, and consortia between external and African partners have
84 demonstrated great potential for reinforcing research human and institutional resources, power asymmetries
85 and inequitable relationships between partners remain key issues (25–28).

86
87 Survey studies by African researchers in collaboration with WHO Regional Office for Africa have
88 shown general improvement in strengthening national health research systems over the past two decades
89 on the aggregate level, based on data collected from national health research focal points and the literature
90 (29–33). Knowledge from evaluations and case studies on national health research system strengthening
91 provide insight into issues like infrastructure, training, and political will (34–40), which, with issues of
92 adequate financing, have persisted across time although systems and contexts vary (41,42). Yet, investment
93 in health research in Africa remains inadequate to meet these needs, and there are disparities in health
94 research capacity within and between the five regions of the continent (43,44).

95
96 Regional organisations offer one route through which regional cooperation may extend to health
97 research and potentially contribute to reducing differences in national health research capacity. Our
98 previous qualitative work with national health science research decision-makers in Africa found the role of

99 regional bodies (which have pre-existing cooperation structures, mechanism, and processes) have been
100 underexplored. Health, science, and higher-education decision-makers in government shared that they saw
101 opportunities for using regional organisations to include health sciences research as a domain of cooperation
102 (where there were not already dedicated regional bodies for this such as in Western and Eastern Africa)
103 (24). In a more recent qualitative study, we found that regional organisations in Africa are more involved
104 in governance and research use and dissemination, than financing or infrastructure development – with
105 capacity strengthening activities more focused on individual human resources (45). Some regional
106 organisations have policies specific to health research, such as the African Union Development Agency’s
107 *Health Research and Innovation Strategy for Africa (2018-2030)* (46) and the WHO’s Regional Office for
108 *Africa Research for Health Strategy for the African Region (2016-2025)* (47). The mandates of regional
109 organisations influence their involvement however, many identified gaps in coordination, infrastructure,
110 and advocacy for in strengthening health research systems (45). Health research regionalism could foster
111 interdependence to harness the knowledge, capacity in member states, and coordinate resources,
112 information, and materials to benefit national health research systems more equitably.

113

114 Acknowledging this history of regional bodies on the African continent and their health
115 programmes and policies (2,3,48–50), with emerging knowledge about their roles in health research
116 (5,39,45), there is still much unknown about the constellation of actors in regionalism for health sciences
117 research (HSciR). Therefore, this study aims to map the state-based regional organisations in Africa
118 involved in HSciR, characterise the network of actors, and test the hypothesis of whether regional network
119 strength correlates with national health research indicators. By exploring the nature of the network of state
120 actors interacting in regional bodies, the paper visualises this landscape and identifies key strengths,
121 limitations, and implications of these interactions for regional cooperation to strengthen health research.

122

123 **Methods**

124 We define regional organisations as state-based membership organisations with a specific
125 geographic mandate for at least one of the five African regions as defined by the African Union (AU) (51)
126 or language mandate. This definition of regional organisations adopts a “state-centric perspective” of
127 regional cooperation from international relations (52). We included organisations with direct or indirect
128 interests in health research, health, or health systems. This includes regional economic communities and
129 specialist regional organisations in health or related sectors like higher education; science; and
130 development.

131

132 We developed an initial list of regional organisations informed by interviews with national health
133 sciences research stakeholders from nine African countries conducted within a previous research project
134 (24). We reviewed organisations’ websites, governing documents, policies, and strategic plans available
135 online to assess evidence of their interest or involvement in strengthening at least one domain of health
136 research systems (53) and to identify other relevant regional bodies operating on the continent. This process
137 was repeated for identified organisations until no new bodies were found. Finally, external partners and
138 networks with expertise in regional health cooperation and health research in Africa corroborated this list.
139 The list of stakeholders is available in Supplemental File 1.

140

141 Focusing on African-led regionalism, the network analysis excluded international organisations
142 with a regional presence in Africa, even if they are active in health and have African governance structures.
143 International organisations, like the WHO Regional Office for Africa (WHO AFRO), have well-
144 documented involvement and influence on African health research agendas and capacity as evidenced by
145 the ongoing studies by WHO AFRO using data from the African Barometer collected from health research
146 focal points in country (32) or similar studies with the WHO Regional Office for the Eastern Mediterranean
147 (WHO EMRO) (54,55). Our qualitative research with informants in regional organisations confirms and
148 elaborates on the important roles played by these two WHO regional offices (45). However, we excluded
149 United Nations specialised technical agencies to highlight African-initiated and owned regional institutions.

150 The governance structures and interactions of international organisations with regional offices extend
151 beyond African states and therefore, their inclusion in our SNA would inhibit our ability to visualize and
152 understand uniquely African-led state membership networks.

153
154 We designed a Social Network Analysis (SNA) to measure the number of connections between
155 African states through regional organisations related to health research. The SNA privileged sub-
156 organisations of continental groups with more specific geographic mandates over secretariats to better
157 capture regional networks. We elected for this inclusion and exclusion criteria to clearly delineate between
158 continental organisations (i.e., bodies that represent the entirety, or large part, of the African continent) and
159 regional organisations (i.e., bodies with membership of geographically grouped countries). Therefore, in
160 lieu of including continental organisations (e.g., Africa CDC or the African Development Bank), we elected
161 to include their regional networks or counterparts (e.g., the five Africa CDC Regional Collaborating Centres
162 or the five African Development Bank Regional Integration Offices). By doing so, the SNA is better
163 powered to focus on the unique contours of African regions as defined by the AU (51).

164
165 An adjacency matrix was created for each included organisation, extracting data on member states
166 of each organisation included in the stakeholder list (see Supporting Information File 2). The individual
167 country was designated the node with edges representing connections via regional organisations. Weighted
168 degrees (or the number of connections to and from a country) were calculated by summing each matrix.
169 We designed this weighting system to highlight countries that connect multiple times through different
170 organisations.

171
172 Network data was analysed using the open-source SNA software, *Gephi (version 0.9.2)* with
173 additional analysis to determine standard deviations and group statistics by region (56). This SNA focused
174 on eigenvector centrality (EC)—a relative measure of network influence that benefits countries with more
175 connections to other highly connected countries. The mean EC for each region were also calculated to

176 identify those with a higher concentration of centrally connected countries. Network density (the number
177 of observed country connections as a proportion of the total possible connections) and network diameter
178 (the number of connections between the two most distant nodes) were calculated to describe the network.
179 We drew definitions and guidance from general sources on the SNA method and sources specific to SNA
180 in health policy and systems research (57,58).

181
182 The results of the SNA were used to test a hypothesis that increased membership to regional
183 organisations for health or health research would be correlated with higher health sciences research
184 performance metrics. Informants highlighted that regional organisations may facilitate health research
185 collaboration, information sharing, and knowledge dissemination (24). Therefore, we selected four
186 indicators based on the potential that they might be associated with regionalism collaboration: gross
187 domestic expenditure on R&D (GERD) as a percentage of gross domestic product (GERD/GDP); clinical
188 trials per million population (TRIALS); patent applications per million population (PATENTS); and
189 researchers per million population (RESEARCHERS). The data set used was from a previous study on
190 metrics of African health sciences research capacity (44). The hypothesis was tested using a Pearson's r
191 test to determine correlation coefficients, with a significance level set at $p=0.05$.

192 193 **Strengths and Limitations**

194 The analysis did not weigh regional organisations by subject matter or relative influence. This
195 means that regional organisations with high policy area relevancy, like the West African Health
196 Organisation, the East African Health Research Commission, or the *Organisation de Coordination pour la*
197 *Lutte contre les Endémies en Afrique Centrale* were counted the same as organisations with less direct
198 connection to health, like the Indian Ocean Commission, the Arab Maghreb Union, or the Community of
199 Sahel-Saharan States. This could reduce the SNA effect size as regions that engage more comprehensively
200 through a smaller number of specialised organisations would not be emphasised. Ideally, we might weigh
201 this analysis by organisation-level HSciR-related expenditures, however, this information is not readily

202 available to the public. Future analysis would benefit from more financial transparency from regional
203 organisations.

204
205 Our focus on regional cooperation for health research between African states excluded private and
206 public-private partnership organisations. Thus, our SNA of regional stakeholders does not capture
207 countries' network connectivity through private and hybrid organisations nor their potential effects. For
208 example, in our initial landscape review, we identified several private organisations and NGOs active in
209 the HSciR space. These organisations are likely strong contributors to the regional HSciR efforts. Also, our
210 focus on an African state-centric regional cooperation, relationships and collaborations with donors and
211 external partners are not included. While this may be seen as a limitation to the analysis given the well-
212 documented contributions of international collaborations and investment to support research capacity
213 strengthening, the purpose of this SNA to centre state actors in collaboration builds on our findings related
214 to the coordination and advocacy gaps identified by regional organisations for their roles in strengthening
215 health research systems (45). The scope of this SNA provides a picture of opportunities for inter-state
216 regional cooperation on HSciR development using existing regional cooperation structures and not an
217 analysis of all networks operating in the research capacity strengthening space in Africa. That said, the
218 inclusion of regional organisations that are not RECs or regional health (sector) organisations but have
219 direct implications and involvement in areas of health research systems is a key strength of our method (e.g.
220 the African Regional Intellectual Property Organization and the *Conseil Africain et Malgache pour*
221 *l'Enseignement Supérieur*) Given the heterogeneity of subject matter included in our SNA, the expansion
222 of the inclusion criteria to include non-state-based and external actors would limit interpretability for state-
223 based networks.

224
225 Availability and missing data for metrics of health sciences research capacity are additional
226 limitations for interpreting the insignificant association between regional organisation membership and
227 national performance. The dataset was comprised of most up-to-date statistics as of 2017, or closest

228 available year (e.g., 2016 for patents) (44). While most regional organisations were established much
229 earlier, some organisations were founded in the 2010s. For example, the Africa CDC was established the
230 same year many of the included metrics were collected. Therefore, the potential impact of these younger
231 organisations would not be represented in this analysis. Thus, the implications of the Pearson test should
232 be interpreted with caution, as a first step to pilot such as assessment.

233

234 **Results**

235 In total, this study identified 21 unique state-based membership regional organisations that are
236 either directly or indirectly involved in health research policy or strengthening activities in Africa. Among
237 these, 26 relevant sub-organisations were identified with either more specific geographic mandate or
238 additional policy area specialisation. By sector, health organisations (n=17) were the most represented,
239 amongst representation from economic (n=11), development (n=8), science (n=7), political (n=2), and
240 higher education organisations (n=2). Overall, 34 organisations were included in the SNA with the full list
241 available in Supporting Information File 2. Below we present the results on the connectivity of states and
242 the characteristics of regional networks, and the analysis of the relationship between regional connectivity
243 and national health research capacity. The full country level SNA summary is available in Supporting
244 Information File 3.

245

246 We found that African countries are tightly networked around health research in regional
247 organisations with nearly 80% of possible connections between countries currently present (network
248 density of 0.795). This dense network is complemented by a small network diameter of three, which
249 indicates that information can theoretically spread efficiently throughout the network and no country is
250 entirely excluded. These results are illustrated in Figure 1 with descriptive statistics in Table 1.

251

252 This dense network is further evidenced by a high EC score across countries (mean=0.85±0.19).
253 This distribution indicates that most countries hold well connected, central positions in the network.

254 However, there are connective outliers such as the Sahrawi Arab Democratic Republic ($EC=0.12$). The
255 country's unique political status, being recognised by the AU but not the United Nations, could explain
256 limited connections with other countries.

257
258 While no individual country stands out as uniquely central, when SNA statistics are grouped by
259 AU region, West and East Africa are better networked for health research and have a higher distribution of
260 well-connected countries compared to other regions. This SNA grouped two statistics by region, weighted
261 out-degrees (the number of single direction connections from country X to country Y, excluding reciprocal
262 connections from country Y to country X), and EC. West Africa is the most networked region with an
263 average 134 ± 30.2 connections per country. The majority of these connections are to other West African
264 countries (mean= 87 ± 7.7). This is a striking result, as the region's internal connectivity outsizes all other
265 regions. In Northern Africa, for example, each country only maintains an average 19 ± 4.6 degrees of
266 connection within other North Africa countries.

267
268 East Africa has the second highest number of connections, with an average of 111 ± 24.1
269 connections per country. In comparison to West Africa, less than half of Eastern Africa's connections are
270 to other East African countries (mean= 51 ± 13.6). This means that East Africa maintains a looser internal
271 network, especially among peripheral countries (mostly, the island-nations) but has stronger connections,
272 proportionally, with the rest of the continent than West Africa.

273
274 Being more networked, West and East Africa also maintain more central and therefore, potentially
275 influential positions in the continental network. West Africa and East Africa had the highest mean EC
276 values of any region (0.88 ± 0.18 ; 0.94 ± 0.04 respectively). This could be explained by the presence of more
277 specialist sub-organisations for health and health research within their regional economic communities,
278 such as the West Africa Health Organisation and East African Health Research Commission. Also, these
279 two regions have the greatest number of countries of all AU regions, which would amplify their impact in

280 the network. Northern Africa maintained the least central position in the network with a mean EC of
 281 0.77 ± 0.29 , followed closely by Southern Africa (0.78 ± 0.20).

282

283 **Table 1.** Summary Table of SNA Statistical Measures

		Weighted Out-Degree	Average Per Country (SD)	Mean Eigenvector Centrality (SD)
Central Africa	Central Africa Total	858	95 (24.5)	0.81 (0.16)
	Central Africa	328	36 (8.0)	
	Eastern Africa	213	24 (10.9)	
	Northern Africa	47	5 (3.2)	
	Southern Africa	63	7 (6.2)	
	Western Africa	207	23 (10.0)	
Eastern Africa	Eastern Africa Total	1560	111 (24.1)	0.94 (0.04)
	Central Africa	213	15 (6.1)	
	Eastern Africa	714	51 (13.6)	
	Northern Africa	117	8 (2.2)	
	Southern Africa	278	20 (10.3)	
	Western Africa	238	17 (4.7)	
Northern Africa	Northern Africa Total	487	70 (30.2)	0.77 (0.29)
	Central Africa	47	7 (10.8)	
	Eastern Africa	117	17 (6.3)	
	Northern Africa	134	19 (4.6)	
	Southern Africa	47	7 (10.2)	
	Western Africa	142	20 (3.1)	
Southern Africa	Southern Africa Total	876	88 (30.8)	0.78 (0.20)
	Central Africa	63	6 (12.9)	
	Eastern Africa	278	28 (3.3)	
	Northern Africa	47	5 (8.4)	
	Southern Africa	372	37 (6.1)	
	Western Africa	116	12 (2.5)	
Western Africa	Western Africa Total	2003	134 (30.2)	0.88 (0.18)
	Central Africa	207	14 (5.7)	
	Eastern Africa	238	16 (3.4)	
	Northern Africa	142	9 (4.3)	
	Southern Africa	116	8 (15.5)	
	Western Africa	1300	87 (7.7)	
Total Weighted Out-Degree		5784	105 (35.6)	

Network Mean Eigenvector Centrality (SD)	0.85 (0.19)	
Network Density	0.795	
Network Diameter	3	

284

285 Considering the dense network and regional poles, we explore the possible associations between
286 connectivity through regional organisations and national health research capacity. We produced correlation
287 coefficients between weighted degree (mean=210.32±71.21), or the number of connections to and from a
288 country, and four health science research metrics—GERD per GDP (mean=0.35±0.24), researchers per
289 million population (mean=193.15±380.67), clinical trials per million population (mean=11.64±15.67), and
290 patent applications per million population (mean=4.67±10.87).

291

292 GERD/GDP and TRIALS were not correlated with weighted degree. We observed a small negative
293 correlation between RESEACHERS and weighted degree with a correlation coefficient of $r(33)=-0.16$,
294 $p=0.3626$. The strongest relationship was a negative correlation between PATENTS ($r(21)=-0.36$,
295 $p=0.08915$). Without achieving statistical significance for any of these coefficients, the results of this initial
296 assessment reject the hypothesis that increased connection through regional organisations is associated with
297 better national health science research metrics. The summary table of results is included in Table 2.

298

299 **Table 2.** Summary Table of Results for Pearson-R Test of Weighted Degree and Health Science Research
300 Metrics

301

Variable	Degrees of Freedom	Mean (SD)	Correlation Coefficient (P Value)
Weighted Degree		210.32 (71.21)	
GERD Per GDP	29	0.35 (0.24)	0.04 (p = 0.8238)
Researchers per Million Population	33	193.15 (380.67)	-0.16 (p = 0.3626)
Clinical Trials per Million Population	52	11.64 (15.67)	-0.05 (p = 0.7014)
Patent Applications per Million Population	21	4.67 (10.87)	-0.36 (p = 0.08915)

302

303

304 **Discussion**

305 The results from this SNA present an optimistic case for African regionalism for health research
306 despite statistically insignificant results about its relationship to national health research performance. With
307 21 unique organisations and an additional 26 specialised sub-organisations, the African continent houses a
308 vast and dense network of regional bodies related to health research systems. Our results show that
309 governments are densely networked through regional cooperation with very few states being left on the
310 periphery. These findings support claims that the design of African state-based regional networks for
311 cooperation in matters of health research systems is suited for efficient communication between state actors.
312 This is an important asset to national health research systems, as, theoretically, lessons learned in one
313 locality could easily be shared throughout the network either in continental forums or in more specialised
314 regional discussions. One key challenge to this is that regional organisations tend to be organised by policy
315 sector (45), while health research systems are multi-sectoral (24,59,60). This means that the health, science
316 and innovation, and higher education sectors need to coordinate at the national level to incorporate such
317 information coming through state representatives via respective ministries or departments to various
318 regional organisations (24,33).

319
320 However, without significant correlations between increased regional connections and improved
321 national health research performance, the benefits of African regionalism for health research are
322 inconclusive and merits further exploration. For instance, a critical perspective on the selection and use of
323 global metrics to measure performance of health research systems in Africa is needed, which we have
324 reflected upon elsewhere (61). The HSciR performance metrics which have been developed, defined,
325 collected, and disseminated for the most part by institutions in the global north have important
326 consequences when they are recommended or imposed as indicators for use in decision-making and
327 monitoring health research systems in other contexts; there are several research and collaboration processes
328 related to power, equity, and ownership hidden behind and within these numbers (61). Despite
329 methodological, ethical, political and practical issues with HSciR performance evaluation and use of these
330 metrics for African institutions (61–63), these are among the core set of indicators used to track, benchmark,

331 and analyse HSciR development and performance at a global level in the (64–66). In our work mapping
332 available indicators for HSciR in all 54 African countries, we found a nuanced picture, whereby health
333 research systems performed differently across indicators using the state jurisdiction as the unity of analysis
334 (national level) (44), a finding which has also been shown in studies using indicators of knowledge
335 economies in Africa (67). Through the lens of a national jurisdiction, countries do not perform
336 homogenously across metrics, showing different areas of strengths influenced by several factors. The
337 snapshot of performance may look different if using a regional or institutional level of analysis.

338

339 Nevertheless, within these limitations, the SNA results point to key opportunities to use state-based
340 regional cooperative networks in strategic and targeted ways. Most prominently, some higher-performing
341 countries in health research are not central or deeply engaged in the broader network. South Africa, for
342 example, performs well on key health research metrics like the number of clinical trials per capita and
343 GERD per GDP (44). It also maintains world-class universities, houses the only vaccine manufacturer in
344 sub-Saharan Africa, and controls 70% of sub-Saharan pharmaceutical production (68). Yet, South Africa's
345 engagement with the regional cooperation system is in the lowest quintile. Given the dense system
346 dynamics, further engagement from South Africa and other states with higher performing national health
347 research systems could benefit neighbouring regional countries.

348

349 Beyond individual countries' connections, the structures of regional cooperation reflect the history
350 and consequences of colonial exploitation. Western Africa's position as an outlier with strong intra-regional
351 connectivity for health research could be rooted in its pattern of regional economic integration more broadly
352 as an approach to support development, peace and security. Some argue that regional cooperation was an
353 imperative upon independence, not least for economic and political reasons, but also to bridge populations
354 and culture towards shared identity and governance across borders imposed by French and British colonists
355 (69,70). Cooperation between Western African states also built on a history of dense commercial, social,
356 and political networks before colonisation (70). Francophone countries in West Africa maintained regional

357 organisations prior to the establishment of the Economic Community of West African states in 1975 (69)
358 — evidenced by the *Organisation de Coordination et de Coopération pour la Lutte Contre les Grandes*
359 *Endémies* (est.1960), which merged with the Anglophone West African Health Community (est. 1972) to
360 form the West African Health Organisation in 1987.

361
362 In contrast, Northern Africa’s weaker position in the continental network could also be explained
363 by historical ties with the Middle East. Nonetheless, North African countries offer useful lessons for
364 building health-related industries such as Egypt’s predominate generic manufacturing capacities (71) and
365 for strengthening the legal framework for health research and investment in innovation such as Tunisia’s
366 law on scientific research orientation (24). Encouraging and facilitating North African countries to develop
367 a more connected position in African regionalism for health research could bolster opportunities for
368 learning, networking, and potentially increased performance across the region, and indeed continent.

369
370 National decision-makers’ awareness and appreciation of health research is a challenge for high-
371 level commitments to strengthen health research systems domestically and through regional organisations,
372 which is why advocacy is key to influencing political will and interest (45). But as national research leaders
373 and other advocates make the case for prioritising health research in their countries, the incentives may be
374 less clear for states with stronger research capacity or higher performance to engage with regional
375 organisations for this even if senior civils servants have expressed interest in more inter-regional
376 cooperation. Therefore, for regionalism for HSciR to prosper, health researchers, leaders, and regulators
377 need to advocate to government and state representatives in regional organisations on the opportunities and
378 benefits of using regional organisations as networks for strengthening national health research systems
379 through learning, exchanging, and cooperating..

380

381 **Future Areas of Study**

382

383 In this investigation, increased connectivity was not shown to produce meaningful effect when
384 assessed with basic tests of association at a single time point. With this, the null hypothesis must be explored
385 further. Deeper analysis of longitudinal trends at the national or continental levels could provide key insight
386 into the strengths and limitations of regional bodies. However, it was quite difficult to validate inception
387 dates for many regional organisations. In some instances, regional organisations that are currently active
388 today were founded out of previous organisations. Therefore, without careful consideration at the initial
389 design of the study, it would be difficult to create a validated longitudinal dataset.

390

391 We elected not to pursue additional hypothesis testing after the initial conclusion as HSciR metrics
392 are difficult to validate with publicly available information., especially as there are no uniform data
393 collection or reporting standards across the continent (44). We believe further research that engages
394 critically with HSciR metrics could provide insights into the potential role of state-based cooperation
395 networks for national health research systems.

396 There is an underlying question to whether assessing a regional organisation by performance
397 indicators at the national level is the most effective way to capture effect. Aggregating health research
398 indicators to the regional level is one possibility, but this would reproduce issues with data availability and
399 appropriateness. Indeed, the relevance and use of standard international metrics for evaluating health
400 research performance in African countries is not without critique and limitations as well (61). Another
401 would be to review health research policy diffusion or research uptake in a regional network as a measure
402 of cooperation effects. For example, research has shown that African regional economic communities have
403 incorporated health to varying degrees into their policy portfolios, but there is still a lack of knowledge
404 about their impacts on national health or health research systems (2). Measuring the impact of regional
405 cooperation should also account for challenges of multi-level governance (45).

406

407 **Conclusion**

408 In this effort to characterise the African network of state-based regional cooperation for health
409 research systems, we confirmed that a dense and inclusive network of countries exists through regional
410 organisations. These results provide an encouraging view of intra- and inter-regional connectivity among
411 state actors. However, evaluating the impact of regional cooperation on strengthening health research and
412 identifying mechanisms to increase interaction of North and Southern Africa in the network are core issues
413 to be addressed in African regionalism for health research improvement. As these findings join a growing
414 body of literature on health regionalism in Africa, we think they underscore the importance of research
415 needed to better understand the processes, outcomes, and impacts of south-south state cooperation at the
416 regional level on policies, systems, and capacity for health research.

417

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419
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639 **Supporting Information Captions**

640
641 **Supporting Information File 1. Stakeholder List** – A list of African regional organisations identified
642 during review.

643
644 **Supporting Information File 2. Social Network Analysis Dataset** – The underlying dataset that was
645 used to generate the social network analysis.

646
647 **Supporting Information File 3. Social Network Analysis Country-Level Summary Statistics** – A
648 summary table of the social network analysis statistical results combined with country-level health
649 science research metric outcomes.

650
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