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Emergent patterns in global health diplomacy: a network analysis of the resolutions adopted by the World Health Assembly from 1948 to 2022

Didier Wernli [ID],[1,2] Jean-Luc Falcone,[2] Stephan Davidshofer,[1] Kelley Lee [ID],[3] Bastien Chopard,[2] Nicolas Levrat[1,4]

[1]Global Studies Institute, University of Geneva, Geneva, Switzerland
[2]Department of Computer Science, Faculty of Science, University of Geneva, Geneva, Switzerland
[3]Faculty of Health Sciences, Simon Fraser University, Burnaby, British Columbia, Canada
[4]Faculty of Law, University of Geneva, Geneva, Switzerland

Correspondence to
Professor Didier Wernli;
didier.wernli@unige.ch

ABSTRACT

From a complexity perspective on governance, multilateral diplomacy is based on interactions between people, ideas, norms, policies and institutions. This article uses a computer-assisted methodology to better understand governance systems as a network of norms. All World Health Assembly (WHA) resolutions that were available from 1948 to 2022 were collected from the WHO Institutional Repository for Information Sharing (IRIS) database. Regular expressions were used to identify how resolutions cite other resolutions and the resulting relationships were analysed as a normative network. The findings show that WHA resolutions constitute a complex network of interconnected global health issues. This network is characterised by several community patterns. While chain-like patterns are associated with specific diseases programmes, radial patterns are characteristic of highly important procedural decisions that member states reaffirm in similar situations. Finally, densely connected communities correspond to contested topics and emergencies. While these emergeng patterns suggest the relevance of using network analysis to understand global health norms in international organisations, we reflect on how this computational approach can be extended to provide new understandings of how multilateral governance systems work, and to address some important contemporary questions about the effects of regime complexity on global health diplomacy.

INTRODUCTION

The WHO is the United Nations (UN) specialised agency dedicated to the 'attainment by all peoples of the highest possible level of health'.[1] With 194 member states, WHO employs more than 8000 staff distributed across three levels of bureaucracy (headquarters, 6 regional offices and 150 country offices).[2] For decades, WHO was the leader in international health cooperation, but its role was challenged from the late 1980s onwards. More international organisations became involved in health issues at a time when WHO

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ As the plenary decision-making body of the WHO, the World Health Assembly (WHA) adopts each year several non-binding resolutions and decisions on both procedural issues and matters of health concern. While it appears that in recent years a diversity of countries is engaged in shaping the global health agenda, it has been shown that the issues covered by WHA are guided by different considerations beyond the burden of diseases.

WHAT THIS STUDY ADDS

⇒ This study provides the first comprehensive analysis of the resolutions adopted by the WHA since the creation of the WHO in 1948. It demonstrates that the normative work of the WHO is a complex network, where many pressing global health issues are interconnected and some of them are more central than others. Different types of community patterns of the network are associated with important features of the issues being addressed. While chain-like patterns are associated with specific diseases programmes, radial patterns are characteristic of important procedural decisions that member states reaffirm in similar situations. Finally, densely connected communities correspond to contested topics and emergencies.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The proposed computational approach to study global health governance may be extended to other layers of documents from the WHO and other international organisations. This may help address questions such as why and how issues get prioritised at the WHO and what are the drivers of successful norms entrepreneurship and interorganisational collaboration. Furthermore, our findings may help health diplomats identify relevant material from past negotiations, understand interlinkages between issues and make informed choices on how and when issues should be addressed.

faced several operational, financial and leadership challenges.[3] Despite this dispersal of global health governance authority, '[…] the legitimate order still resides in multilateralism and first and foremost in WHO, because of WHO's constitutional mandate for the establishment of norms and standards, high level of legitimacy through the representation of states and unique treaty-making power'.[4] The COVID-19 pandemic has re-emphasised the importance of multilateral diplomacy as an integral part of global health governance.[5]

One of the main roles of WHO is the production of international norms (online supplemental material 1 summarises WHO normative functions) conferred by Article 2 of its Constitution.[6] These normative functions range from the production of technical standards and guidance to the adoption of binding treaties. Despite its extended authority to facilitate the advancement of international law, soft law-making has been the most widely used normative approach adopted by WHO. As Gostin noted, 'The WHO's most salient normative activity has been to create soft standards that are underpinned by science, ethics and human rights. Although not binding, soft norms are influential—particularly at the national level, where they can be incorporated into legislation, regulation or guidelines'.[6]

The World Health Assembly (WHA), the plenary decision-making body of WHO member states, determines the budget, strategic priorities and programme of work for the organisation. The WHA annually adopts non-binding resolutions and decisions on both procedural issues and matters of health concern. Such material provides a rich data set regarding the conduct and outcomes of multilateral diplomacy. While collecting, preparing and analysing a data set such as WHA resolutions can be cumbersome, advances in computational power, automation and methods facilitate these tasks.[7] In addition to yearly sessions since 1948, there have been two special sessions in 2006 and 2021.[8] Resolutions support the development of international norms and may result in the adoption of policy instruments such as global strategies which set out approaches, goals and recommendations to address health issues. Resolutions can also be referenced by intergovernmental treaty negotiations and progressively lead to the adoption of international law.[6] Even when thematic resolutions do not lead to the adoption of formal legal instruments, they help build consensus among member states about the salience of certain issues and ways to address them.

What and how resolutions are adopted by the WHA has received previous scholarly attention. An analysis conducted on resolutions adopted between 1970 and 2013 showed that the issues covered by the WHA are not always aligned with disease burden.[9] A study of member states' contribution to global health governance over 13 years concluded that a diversity of countries are engaged in shaping the global health agenda.[10] To date, however, there has not been a comprehensive analysis of the content of resolutions adopted by the WHA since its creation in 1948. Beyond specific resolutions and topics, we also lack an understanding on how resolutions relate to each other to give rise to emergent systems of norms. Identifying the evolution and overall structure of the web of global health norms over time would build on growing interest in measuring the complexity of normative systems in other issue areas such as development and the environment.[11–14] The methodology used in this article can be understood within the development of the computational social science.[7] While 'computational diplomacy' may refer to the use of computational tools in the conduct of foreign policy, we use 'computational diplomacy' here to refer to the academic interest in using computational and data science approaches (eg, network analysis, text mining, modelling) to better understand the international multilateral system.[15 16]

Given the recognition of the importance of soft law in global health governance,[17] the purpose of this article is to analyse the extent to which WHA resolutions adopted since 1948 have formed a complex normative web and whether this network reflects some important features in global health governance. More specifically we seek to address the following questions: (1) What is the overall structure of the normative web of WHA health norms? (2) Do some issues addressed by the WHA form a distinctive network pattern? (3) What are the topics addressed at the WHA and to what extent has the policy agenda evolved over time? We apply a citation network approach to all resolutions from 1948 to 2022, and then conduct a thematic analysis of their content. We show that the overall network of WHA resolutions becomes increasingly connected over time suggesting a global health complex of interlinked issues. This complex system of norms is both an emergent result of multilateral diplomacy within the framework of a UN specialised agency and the foundation for further effort to collectively address global health issues.

METHODS

Patient and public involvement

This study is based on online search of publicly available web pages and documents. No patients or members of the public were involved in the design of this study.

Background

Citation network is an approach mainly developed in the field of bibliometric analysis.[18] In the scientific literature, when a paper cites another document, the citation is an explicit reference which is usually used: (1) as evidence to back an assertation; (2) to contextualise the issue or research question being addressed; and (3) to endorse or distance themselves from previous methodology or finding. Similar to a scientific network, legal and political institutions produce networks of norms that rests on citation between texts.[19 20] In the normative literature, a citation may refer to a similar situation or 'precedent' which matters for the case at stake. By extension, when an

authoritative body of an international organisation cites another text from its own or from another organisation, it recognises the relevance of a previous position in relation to the issue at stake or aims at reinforcing the normative impact of its latest text by invoking the authority of previous normative actions.

Extraction, preprocessing and coding of WHA resolutions

We used web scraping (ie, a script written in the programming language Python) to automatically retrieve the electronic version of all resolutions adopted by the WHA from 1948 to 2022 from the WHO Institutional Repository for Information Sharing (IRIS).[21] All documents from the IRIS database that contained non-renderable text had already optical character recognition (OCR) performed on them. Files were organised into one folder and named according to the following logic: (name of the organisation and the organ)-(year of adoption)-(number of the resolution according to organisation's way to name resolution). For example, resolutions adopted in 2010 are all named according to the following logic where the first number represents the session of the WHA and the second number describes the specific number of the resolution. In some instances, the documents retrieved from the IRIS database may contain text from different resolutions or several versions of a resolution when the content of a resolution has been revised. These documents were manually edited to keep only the relevant content. In addition, some resolutions have annexes which may be instruments adopted by the WHA such as a global action plan or a declaration of principles. Because these 'governance instruments' are different from the resolutions adopted, we removed the content of annexes from the document's files. This means that the content of annexes is excluded from consideration in this paper.

After preprocessing, all resolutions were imported to ATLAS.ti (V.22 for Windows), a qualitative research software that helps organise documents and analyse their content. ATLAS.ti provides a functionality to automatically code documents using basic and more advanced search functions such as regular expressions. The format of resolutions is largely standardised, composed of a preamble that provides the context of the resolution and a second part consisting of recommendations to the Director-General or member states. A few resolutions have thematic subsections (such as WHA3.71). The standardised format of resolutions extends to the way documents from WHA are cited and referenced. Because WHA resolutions consistently cite other WHA resolutions according to the same logic across documents, namely (WHA)+(number of the session).(number of the resolution), as exemplified by 'WHA63.20', we used regular expression to search and code the whole corpus of resolutions. When using the regular expression 'WHA\d*[.]\d*' and searching for words using the 'Search and Code' function in ATLAS.ti, we initially found 7584 occurrences within the corpus of text. We also searched for resolutions from special sessions of WHO, which are named as (SSA)+(number of the session).(number of the resolution). Three occurrences were found. As ATLAS.ti displays the text content of the quote in the 'quotation manager', the content coded as regular expression provides a string variable (ie, a sequence of alphanumeric characters) that can be used as the basis for building a network of citation between documents. We used the 'quotation report' in ATLAS.ti to export those findings in a way that is suitable for building an edge list (ie, a list of all the edges in a graph) that contains the citing document and the document being cited.

Within the set of documents, we found different types of errors related to the database, documents and OCR (online supplemental material 2 summarises those errors). To identify the sources of errors, we manually reviewed the content of all resolutions in the data set. As a result of the automatised way of searching documents with regular expression, the most frequent error was the omission of a link due to the lack of accuracy of OCR. Another common issue also related to OCR was the identification of a wrong resolution number (eg, WHA49.25 was coded WHA49.3820 and WHA42.26 was coded as 42.2). When errors were found, we corrected them manually by recoding the right quotation name directly in ATLAS.ti. An important benefit of using ATLAS.ti was then to be able to keep track of every step in the process. Since the varying quality of OCR was a major source of errors, we re-applied OCR on the whole data set of resolutions with a performant tool (ABBYY FineReader PDF V.16.0.13.5819) and extracted a new edge list. We then compared both versions of the edge list to check whether the relationships between nodes were the same. Finally, we performed random checks on over around 10% of the data set to check for further sources of errors. In total 275 errors were identified and corrected. After further removing duplicated edges and self-loop (ie, when the name of a resolution appears in the document), the total number of edges was 3242.

Extraction and use of metadata

As the IRIS database contains metadata about resolutions for the years 1948–2019 (the extraction of data was done in September 2022), we imported the entries from the IRIS database into an Excel file. Available data comprises the identifier of the resolution, the title of the resolution and Medical Subject Headings (MeSH). MeSH is a controlled vocabulary used for indexing and searching health-related information. The field 'dc.identifier.govdoc' which provides a unique identifier for resolution was used to match the data with the citation network layer. A few errors were found on the metadata from the IRIS and corrected in the spreadsheet file. For example, some MeSH terms were duplicated in the same resolution and had to be discarded. Additionally, we extracted the title of all resolutions in the data set and searched the text for selected keywords that correspond to some important health issues addressed by the WHA.

Network analysis

The edge list was imported into Cytoscape (V.3.9.1) for visualisation and analysis.[22] Resolutions were defined as the *nodes* of the network while citations were the *edges*. Several metrics of centrality and modularity were computed using a directed network approach. Different subnetworks were produced at different time points, regarding the main topics, the most represented MeSH categories and the giant component of the network. We used several approaches for community detection. Because manual community detection of densely connected communities can be a cumbersome process in densely connected network, we used a community detection algorithm (ie, Leiden algorithm as available by the clusterMaker 2 plugin in Cytoscape V.3.9.1) to identify more densely connected patterns of clustering in the network.[23] Among several algorithms, the Leiden algorithm is a hierarchical clustering algorithm that maximises modularity score for each community.[24]

RESULTS

General description of the network

The overall WHO resolutions network is composed of 3194 nodes and 3242 edges. These nodes correspond to 3185 resolutions that are available on IRIS and 9 cited resolutions which are not available from the WHO website (these 9 resolutions are from the first session of the WHA where documents were not systematically coded as resolutions). The data set consists of 3191 resolutions from the annual sessions and 3 resolutions from the special session of 2006. For each resolution in the data set, online supplemental material 3 provides the identifier, the title, year of adoption and list of cited and citing resolutions. The *degree* of resolutions (ie, number of inward and outward citations) varies from 0 to 45, with an average degree of 2.030, a median of 1 and an SD of 3.634. The degree distribution of the network, that is, the probability that a randomly selected node in the network has a certain degree, exhibits a heavily right-skewed distribution (figure 1). In other words, only a handful of nodes have many connections which may lead to a higher influence level over other nodes. Nearly half of the components (1538 nodes equivalent to 48.15%) have no links at all. It is not known whether these findings are the result of preferential attachment, as is the case for scientific citation networks,[25] or whether they result from implicit rules and conventions regarding the way resolutions are cited. The WHA network has a slightly lower ratio of edges/node (value=1.015) than the network of multilateral environmental agreement from 1857 to 2012 (value=1.34).[13] However, with limited point of comparison with other international organisations, it is difficult to say whether these results are notable or not. Future analysis of normative webs for other organisations will provide opportunities to assess significance.

The total number of WHA resolutions adopted per year reached a maximum in 1950 (123 resolutions) and decreased since then (figure 2). A smaller peak occurred
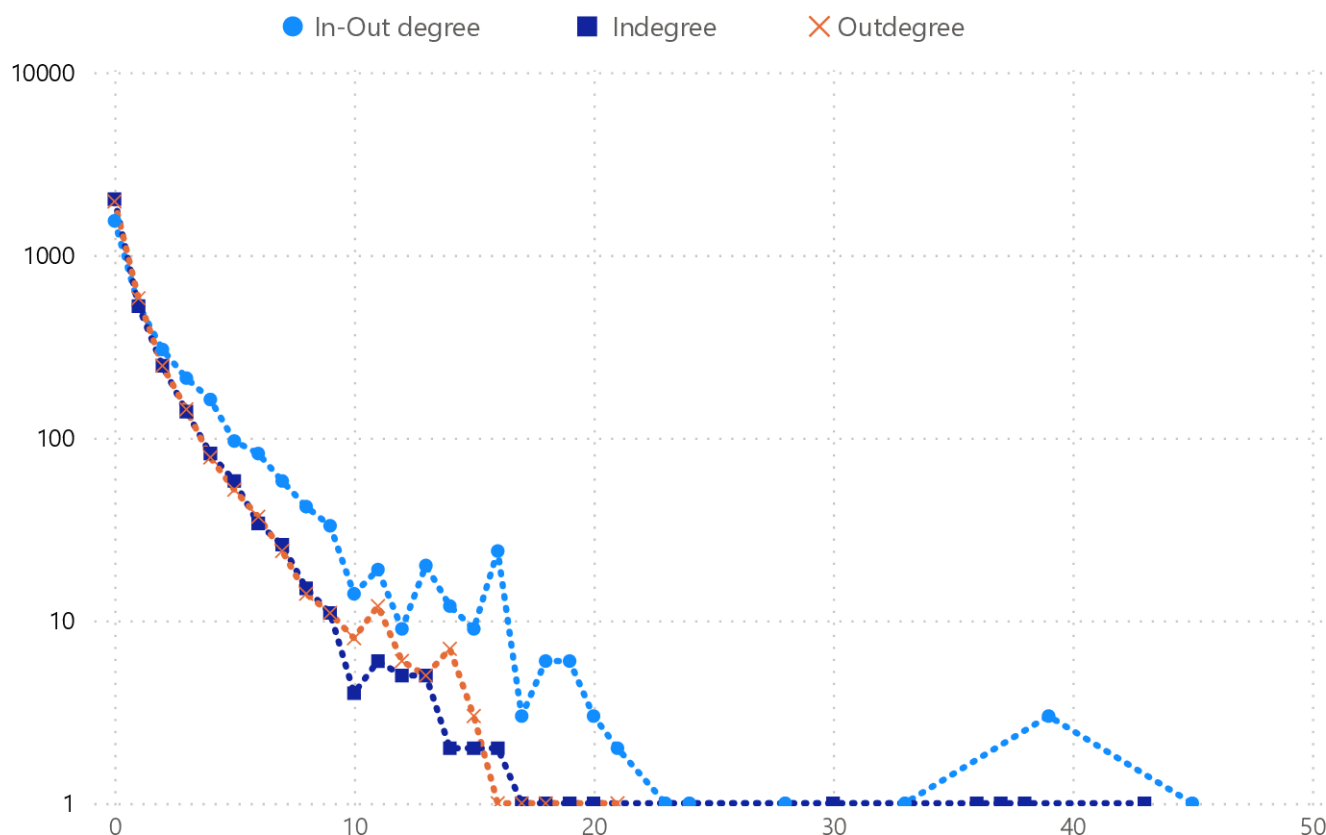

Figure 1 Indegree, outdegree, and in-out degree distribution of WHA resolutions (1948-2022).
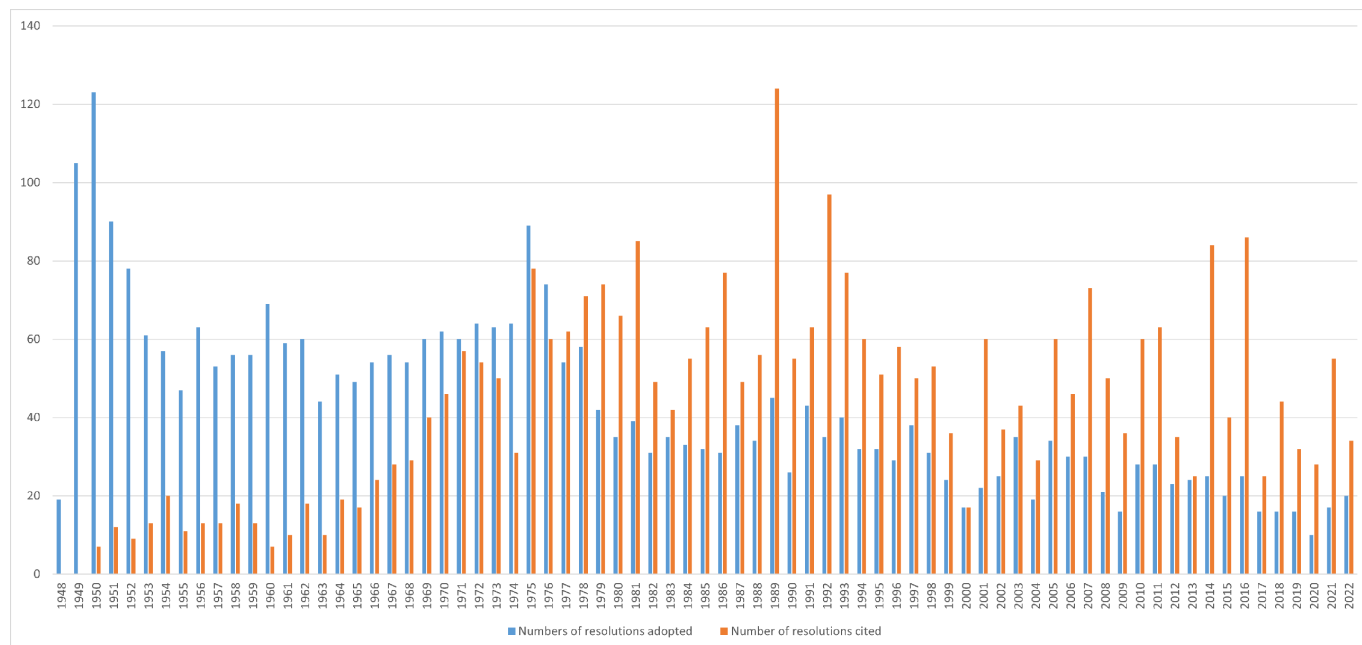
Figure 2 Number of WHA resolutions adopted per year and number of citations per year (1948-2022).

in 1975 (89 resolutions). The total number of citations per year shows an increasing trend over time with a peak of 124 in 1989 (figure 2). Like in bibliometric citation network, resolutions are mostly cited in the year that follow their adoption (online supplemental material 4). There are, however, several outliers with 66 years as the longest gap in the case of resolution WHA74.9 of 2021 'Recommitting to accelerate progress towards malaria elimination' citing resolution WHA 8.30 of 1955 'Malaria eradication'. The ratio between the cumulative number of nodes and the cumulative number of edges has consistently increased over time (table 1), reflecting the growing connectivity of the network. As of the 75th WHA session in 2022, the ratio between edges and nodes was equal to 1.0231. As the network grows more complex over the years, members states have tended to adopt fewer resolutions, and have been more likely to cite previous resolutions. A graph showing the evolution of the network during different periods is available in the

online supplemental material 5. The global clustering coefficient, which measures the extent to which two nodes that are connected to the same node also share a connection, grew markedly from the tenures of Director-Generals Marcolino Gomes Candau to Halfdan Mahler (1953–1988), and then stabilised from 2000 onwards (online supplemental material 6). This pattern of evolution of the clustering coefficient suggests an overall stability of the functioning of the WHA as a governance mechanism. Given the occurrence of several major global health crises including the HIV-AIDS pandemic, SARS-CoV-1 outbreak (2002–2004), Ebola virus outbreaks and COVID-19 pandemic (2019 onwards), one might expect more variations over the past 30 years.

Community detection

Among the 3194 nodes, 51.85% have at least one connection (n=1656). The network presents several clusters, some of which are clearly visible in the overall network

Table 1 Cumulative number of nodes, edges and their ratio at different times related to the successive leadership of the WHO

Director General	Year	Nodes (resolutions)	Edges	Ratio (edges/nodes)
Dr George Brock Chisholm (1948–1953)	1953	476	41	0.0863
Dr Marcolino Gomes Candau (1953–1973)	1973	1613	538	0.3335
Dr Halfdan Mahler (1973–1988)	1988	2302	1456	0.6325
Dr Hiroshi Nakajima (1988–1998)	1998	2653	2144	0.8081
Dr Gro Harlem Brundtland (1999–2003)	2003	2776	2337	0.8419
Dr Lee Jong-wook* (2003–2006)	2007	2889	2545	0.8809
Dr Margaret Chan (2007–2017)	2017	3115	3049	0.9788
Dr Tedros Adhanom Ghebreyesus (2017–…)	2022	3194	3242	1.0150

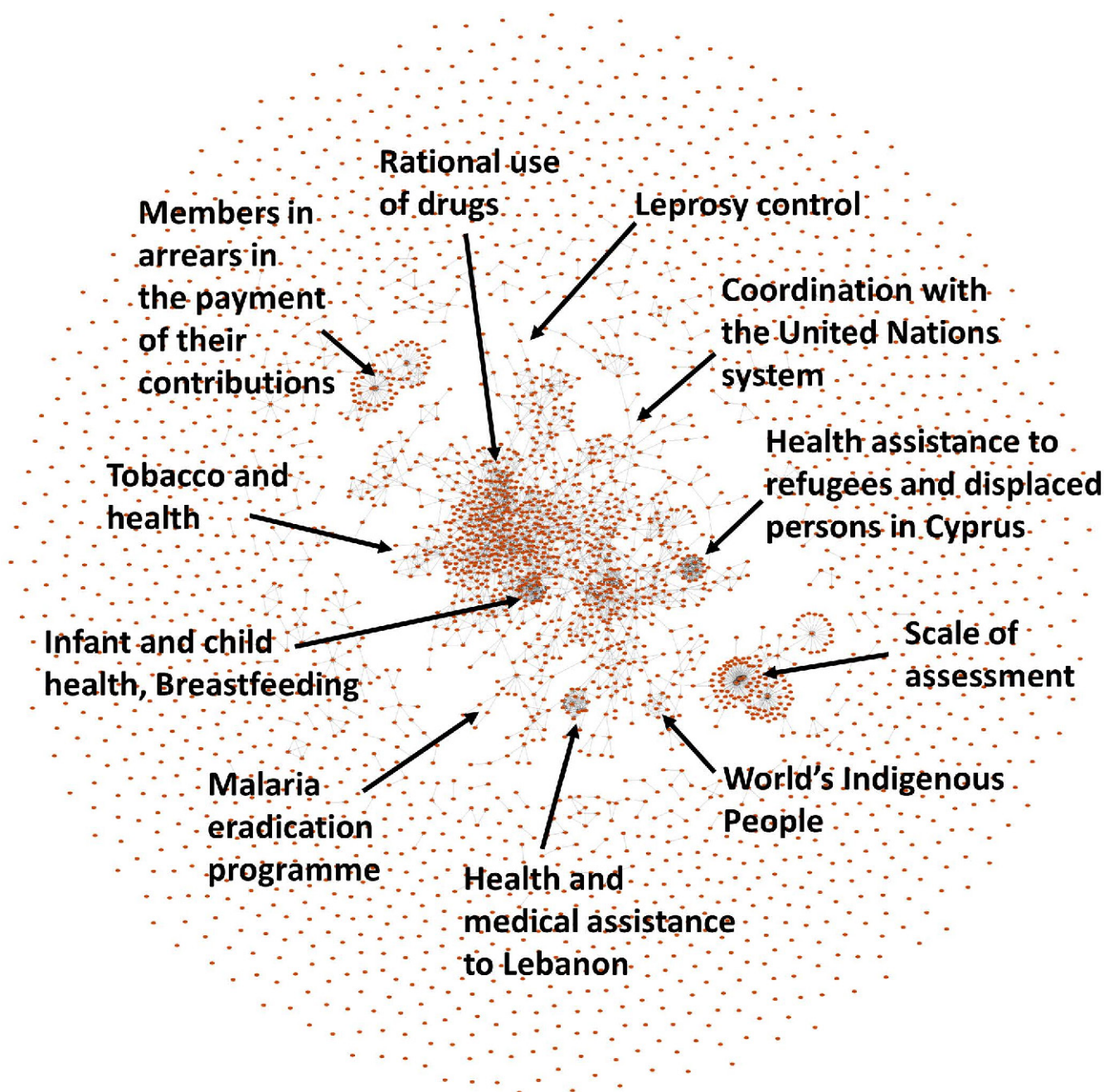*Followed by Dr Anders Nordström from 23 May 2006 until 3 January 2007.

Figure 3 Some visible clusters in the network of WHA resolutions (1948-2022).

(figure 3). A giant component was formed by 1026 nodes connected by 2573 edges, meaning that starting from any node it is possible to find an undirected pathway to reach any other nodes in this component. In addition to the giant component, there are also much smaller groupings of resolutions (online supplemental material 7 shows the distribution of these groupings). A closer look at all groupings reveals some emergent patterns also found in other social networks.[26] First, several resolutions' clusters show a chain-like behaviour where the most recent resolution cites the previous most recent resolutions on the same topic but are not connected to other resolutions. Such a sequential behaviour can be explained when a topic is addressed at the WHA year after year. Several topics (online supplemental materials 8-9) including both health issues (eg, leprosy control, cardiovascular diseases, health problems of seafarers) and procedural issues (recruitment of international staff, headquarter accommodation, report on the World Health Situation) exhibit a chain-like behaviour. While not forming a chain, several resolutions related to smallpox are mostly isolated from other resolutions with a limited number of citations by resolutions outside the topic. Chain and chain-like behaviour suggests a vertically controlled process of incremental change regarding a well-delineated topic. By extension, it may reflect a siloed governance approach to address a health issue. Taking edges as a proxy for the diffusion of a norm,

chain-like behaviour may be less likely for an emerging norm to cascade into new areas.

Beyond chain-like behaviour, we observe radial-like clustering which corresponds to a single or small number of resolutions at the centre, and several peripherical resolutions that are (almost) all connected to the centre but not connected between themselves. In other words, a radial structure is organised around or with a few central resolutions. In the WHA resolutions data set, we found that radial and radial-like structures are all related to procedural and financial issues such as the scale of assessment of member states, members in payment arrears, the status of annual contributions collections and incentives to promote timely payment of assessed contributions (online supplemental materials 10-11). Overall, 154 resolutions are incoming relations to just 7 resolutions at the centre of a radial structure, suggesting the importance of these topics for the WHA. These findings may be indicative of highly important decisions/precedents that were taken after intense negotiations and that member states want to refer to because of non-conforming behaviour. In the context of the funding of WHO, the presence of such a radial pattern on the scale of assessment from the period from 1955 to 2001 may also signal the unwillingness of some member states to fundamentally reform the way the core budget of WHO is funded. This finding could help explain why such multilateral formal international organisation are not adapted to tackle emerging challenges and are increasingly replaced by ad hoc quasi-international organisations as tools of governance (such as Conferences of the parties which is instituted by the UN Framework Convention on Climate Change instead of a proper international organisation for the environment).

We identified some densely connected resolutions clusters on several important health issues including child health, essential drugs, HIV-AIDS and health systems strengthening (online supplemental material 12-13). This in turn is further reflected by some network metrics. For example, authorities (resolutions cited by many hubs) and hubs (resolutions that cite authoritative sources) were all related to breast-milk substitutes, and infant and young child feeding which have been recurring and contentious global health issues (online supplemental material 14). In addition, some of the most clustered issues also include traditional medicine and indigenous health signalling that some countries are successfully pushing for the inclusion of topics that have traditionally been neglected from the biomedical perspective. The fact that the issue of health assistance to refugees and displaced persons in Cyprus (1975–1991) and, respectively, to Lebanon (1976–1989) are also among the most densely connected clusters, suggest sustained diplomatic activity on issues that are wider humanitarian and security concerns. In the case of Cyprus, the first resolution adopted on the topic (WHA28.47) recalls the resolutions previously adopted by the UN Security Council and General Assembly. In the case of Lebanon, several resolutions started with a statement regarding the principle 'that the health of all peoples is fundamental to the attainment of peace and security' and were in response to the appeal of the UN Secretary-General. The attention of the WHA on both Cyprus and Lebanon not only illustrates the importance of interorganisational interactions which has been a recurring topic addressed by the WHA (see section on thematic analysis below) but may also suggest that broader political issues can spill over from the main organs of the UN system to a 'more technical' specialised agency and become prominent on the WHA agenda.

Beyond the identification of notable patterns in the network of WHA resolutions, some resolutions also play the role of bridging between thematic areas. 'Betweenness centrality' aims to measure the amount of influence a node has over the flow of information in a graph based on the number of shortest paths that pass through an edge.[27] Node betweenness centrality was used to assess issues linkages between issues addressed at the WHA. Resolutions with the highest level of betweenness centrality included the control of non-communicable diseases (NCDs), primary healthcare and health system strengthening and communicable diseases (online supplemental material 15 summarises the 20 resolutions with the highest value of betweenness centrality in the giant component). The four most important resolutions are on highly transversal issues such as (1) primary healthcare (WHA62.12), (2) communicable diseases prevention and control (WHA 48.13), (3) strengthening health systems in developing countries (WHA54.13) and (4) prevention and control of NCDs (WHA66.10). Figure 4 summarises the indegree and outdegree edges of resolution WHA62.12. A closer look at its subnetwork reveals that the resolution connects several issues that were previously separately addressed by WHA including primary healthcare (WHA56.6), sustainable health financing (WHA 58.33), migrant health (WHA61.17) and migration of health personnel (WHA 57.19 and WHA58.17), health promotion (WHA 60.24), strengthening health systems (WHA54.13), health information systems (WHA 60.27), emergency care systems (WHA60.22) and the Millennium Development Goals (WHA61.18). While these resolutions had an average degree of 9, suggesting their importance in the giant component (average degree of 5), they signalled efforts by the WHA to reinvigorate universal access to primary healthcare in the wake of so many disease-focused vertical programmes by the early 2000s.[28 29]

Thematic analysis

The thematic analysis was primarily based on metadata from the IRIS database which uses the MeSH to classify the topics covered by resolutions. After removing 10 duplicate terms, the IRIS database had 8337 MeSH terms associated with 3136 WHA resolutions (1948–2019) (online supplemental material 16). The MeSH terms most frequently associated with WHA resolutions are 'budgets' (n=569), 'financial management' (n=500), 'organization and administration' (n=482) indicating that 'procedural' resolutions are a major part of the
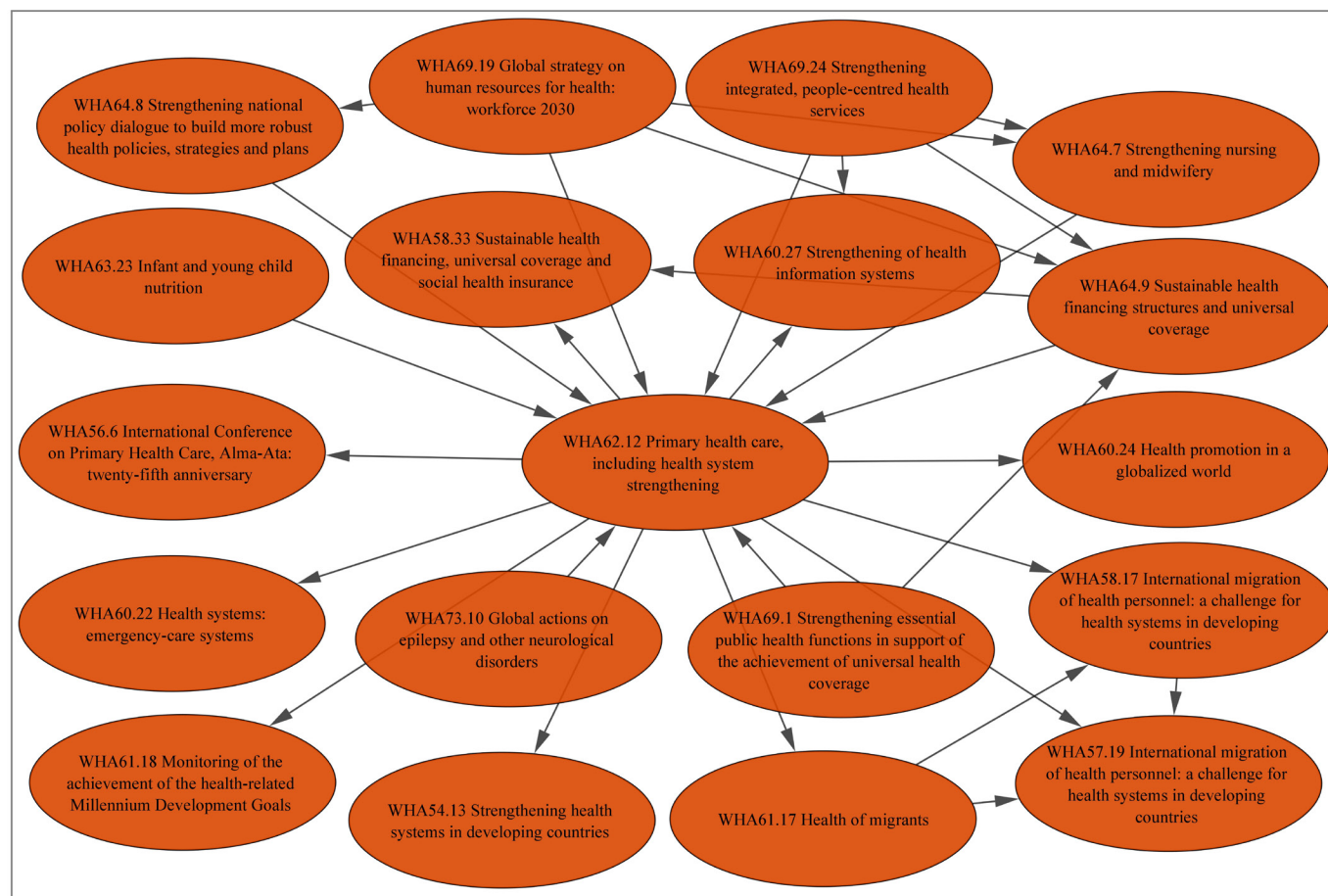
Figure 4 The adjacent neighbours of resolution WHA62.12 on "Primary health care, including health system strengthening" adopted in 2009.

work of the organisation. 'Procedural' resolutions are also more likely to be found outside of the giant component compared with 'thematic' resolutions focusing on health issues. Considering the 50 most used MeSH terms in the data set, the percentage of procedural resolutions with MeSH terms such as 'budget', 'capital financing', 'pensions', 'administrative personnel', 'financial audits' and 'award and prizes' are between 0% and 5% in the giant component. By contrast, resolutions tagged by MeSH terms such as 'nutrition policy', 'health planning', 'socioeconomic factors', 'drug industry' and 'primary health' care are very likely to be found in the giant component of the network (the range is between 83% and 93%). The thematic analysis also revealed a strong focus in the WHA on international cooperation with 271 resolutions on the topic and collaboration with other entities within the UN systems ('interinstitutional relations', n=262). The specific disease that received the most attention is malaria (n=55) which can be explained by the long-term efforts of the organisation to eliminate and then control the disease from the 1960s.

Over time, the most represented topics addressed by the WHA remain relatively stable, dominated by resolutions on 'procedural' matters, when looking at the overall picture (online supplemental material 17). Further

analysis of the MeSH term associated with resolutions that have a degree equal or higher than 1 (and then less likely to be on procedural matter) shows that a variety of topics have been addressed by the WHA. When grouping MeSH terms used at least five times from 1948 to 2019 into 24 meta-categories, 'WHO budgets and finance' has overall ranked in the top of the most important issues addressed by the WHA, followed by 'International cooperation and United Nations systems', 'Health planning, management and policy', 'WHO management and administration', 'Communicable diseases' and 'Health systems and healthcare delivery' (online supplemental material 18). The findings suggest that the agenda of the WHA has never been dominated by one type of issue.

However, as MeSH terms may be attributed to a resolution even if the resolution only partially addresses the issue (ie, not always very specific to the content of the resolution), a complementary analytical approach is to search the titles of resolutions for content that is specific for a health issue (online supplemental material 19 provides a word cloud of the most used words in the titles of resolutions from 1948 to 2022). A closer look at the distribution of some keywords corresponding to specific health issues addressed at the WHA shows that some issues received more attention than others during

different periods (online supplemental materials 20-21). Malaria received the bulk of attention under the leadership of Marcolino Gomes Candau. This happened at a time when the organisation was dominated by the USA and a technical view of international health cooperation.[3] Some major health issues disappeared from the WHA agenda. For example, child health appeared on the agenda between 1948 and 1953, and then disappeared during 1954 to 1973, before returning to a peak of attention in 1989–1998 after the adoption of the International Code of Marketing of Breast-milk Substitutes in 1981. Tobacco control and smoking grew in prominence from 1989 leading up to the adoption of the WHO Framework Convention on Tobacco Control (FCTC) in 2003. However, it then did not appear in the title of any resolutions since 2008, potentially signalling a shift out of the WHA to the FCTC Conference of the parties.

DISCUSSION

To the best of our knowledge, this study conducted the first network analysis of all resolutions adopted by the WHA from 1948 until 2022. Our findings identify the complex structure of this normative network whereby health issues, and the norms that underpin why and how WHO addresses those issues, can be seen as increasingly linked together. The recognition that many global issues are interlinked with other health issues reflect the complexity of advancing global health diplomacy in an interconnected world. At the level of the whole WHA network, our analysis reveals that WHO governance consists of a core of mainly topical resolutions that are highly interconnected, and a periphery of mainly procedural topics that are much less connected except for core financial issues. Further analysis reveals that not everything is connected to everything else to the same extent. More importantly, the structural patterns found in the network seem to correspond to important multilateral diplomacy processes related to the nature of the issues being addressed. In addition to identifying health issues that have classically attracted a lot of attention, the network analysis uncovers issues that have received comparatively less attention in the global health literature. The focused attention on health crises in Cyprus and Lebanon are cases in point. As WHO is also part of the UN system, this suggests that global health governance might be influenced by dynamics taking place at this level. While the analysis is currently limited to citations from WHA resolutions to other WHA resolutions, the findings confirms not only how prolific and wide-ranging the WHA is as the plenary decision-making body of WHO member states, but also the relevance of approaching global health governance as a set of interlinked components.[30] In this regard, network analysis is useful to link different insights together. While the WHO has been criticised for its siloed approach to address global health issues,[31] the analysis suggests that this approach is not the collective will of the WHA but

may relate to the way the WHO has been increasingly funded through earmarked voluntary contributions to specific programmes.[32 33]

The variety of patterns found suggests that the topology of the network is not exclusively a matter of implicit rules and conventions. Several mechanisms may be at play to shape the evolution of this network. First, many resolutions are never cited. One explanation might be that many resolutions are on simple procedural matter and do not require an effort at building a consensus among member states. However, some procedural issues such as the scale of assessment of new member states receive a lot of attention at the WHA. This reflects the fact that funding issues are heavily covered by the WHA. Second, the giant component whereby some resolutions are heavily cited while others are not, are typical of the mechanisms of preferential attachment described in many social networks.[34] However, other mechanisms may be at play. A simple mechanism is parsimony which might explain why a resolution cites only the most recent and/or the most important resolutions related to its main topic. In some cases, one can clearly discern a chain of resolutions where new nodes are added one after the other. Furthermore, the radial configuration found in relation to several procedural issues might reflect the fact that an agreement has been reached on how to address an issue and this agreement is being constantly referred to once the issue happens again. More densely connected forms of clustering might reflect more intense negotiations where Member States level of disagreement is high. Hence, Member States reassert the content of 'all' previous resolutions as part of efforts to move an issue forward. The issue of infant nutrition and breast-milk substitutes, which resulted in the adoption of the International Code of Marketing of Breast-milk Substitutes in 1981, illustrates a topic that was contested and still face several implementation challenges.[35 36]

The capacity to identify linkages between health issues and priorities may have potential relevance for advancing global health governance and policies. On the one hand, multilateral diplomacy requires knowledge of the broader health context so that prioritisation by member states can be informed by an understanding of the most central issues in global health. On the other hand, how global health issues are connected to each other relates to issue framing, which is an important factor for understanding why some issues get addressed while others do not.[37] Competition for attention and resources in global health governance may make it difficult to move a single issue forward. Hence, the capacity to identify norms that are common to several issues may help norm entrepreneurs identify leverage points which may then cascade into the adoption of a shared international norm. Such a pattern was identifiable with resolution WHA48.13 which put together the common challenges associated with the issue of emerging and re-emerging communicable diseases in the 1990s. This may be a necessary (but not sufficient) step to elicit commitment by member states to

address an issue through collective action (eg, in this case the revision of the International Health Regulation).[38]

There are several limitations to the current study. The analysis exclusively focuses on WHA resolutions while resolutions of the Executive Board are also important. The WHA also adopts decisions which are usually shorter than resolutions but may also contain relevant information about global health governance. Another limitation is the choice to remove annexes from the analysis which often corresponds to the instrument adopted by the resolution. In some cases, previous resolutions were cited exclusively in the annex. Furthermore, there is a potential for errors in network analysis despite a multi-pronged strategy to reduce error risks. Given challenges with OCR, we used manual verification of the results and several additional steps to ensure the validity of the findings. While we are not yet confident in reporting word search of the full content of resolutions (hence the use of metadata from the IRIS database and analysis of the title of the resolutions), we are confident that the future quality of the OCR can be substantially improved by using Natural Language Processing. Having access to the full text in a machine-readable format will be essential for better linking the network analysis and the content of the resolutions. There were also limitations regarding the metadata, as the IRIS database has some errors that we discovered while analysing the data set. While corrected, some errors regarding the attribution of MeSH categories could have persisted. It is also not known whether the MeSH categorisation has been consistently applied to WHA resolutions. Finally, at this point of the research, there are also limitations regarding the interpretation of the patterns found in the network of WHA resolutions including a lack of qualitative evidence on what leads an organ such as the WHA to cite and not cite previously adopted resolutions. It will be important to understand what factors motivate citation between resolutions and whether information and communication plays a role.

Despite these limitations, the current data set provides a novel and systematic way of analysing the normative work of WHO and multilateral diplomacy more broadly. Overall, the methodological approach, based on different computational tools, demonstrates that several aspects of global health governance mainly studied by qualitative research can also be interrogated quantitatively. The current approach creates a research agenda on computational approaches to study multilateral diplomacy that could help address important analytical questions regarding global health governance. First, the evolution of topics covered by the WHA over time demonstrates the need to understand the political and historical context of the normative work of the WHO. More precisely, we need to understand what happens during the policy process and which factors shaped the network the way it is. This also means understanding how power is expressed in different forms.[39] Second, we need to understand whether and how changes in the topology of the network potentially influence the effectiveness of the governance system. Previous studies suggest that some features of governance systems can influence effectiveness in addressing some global health issues among several factors.[40] Third, the potential for extending the approach adopted in this article is substantial, linking not only to other types of documents within the WHA and other WHO governance bodies, but also other organisations concerned with global health governance (online supplemental material 22 provides examples of relevant documents). These additional documents may be mapped as new nodes and layers in what would become a multilayered network approach of governance.[41 42]

Within WHO, it would be interesting to compare the network of the agenda documents of WHA (or the resolutions adopted by the Executive Board) and WHA resolutions and test whether some factors may explain whether an issue is more likely to result in the adoption of a resolution by the WHA or not. The multilayer network approach might also teach us about multilevel governance, that is, how WHA resolutions are taken forward at other levels of governance (national and subnational). Finally, given the focus of the global governance literature on understanding regime complexity,[43 44] assessing interlinkages between international organisations appears as a promising way to understand how WHO interacts with other organisations in addressing global health issues and more broadly to study interorganisational collaboration.[45] Given, the common assumption that 194 member states leads to greater plurality and thus representativeness of decisions-making, potential future analysis might be to compare the structure of the WHA normative web with the plenary bodies of World Bank, the Joint United Nations Programme on HIV/AIDS (UNAIDS), United Nations International Children's Emergency Fund (UNICEF) or other international organisations with a health mandate. How are they different? How do they intersect? How does their composition and decision-making processes relate to the structure of their normative webs?

CONCLUSION

This study provides the first analysis of the normative work of the WHA through a document-based network analysis. It emphasises the role of the WHO as a forum where member states adopt global health norms. Resolutions are non-binding, but they are an important mean through which the work of the organisation gets prioritised and in turn reflect the political will of the international community. While the multilateral system remains poorly understood as a system of norms, new approaches and tools are needed to better understand how we can collectively address the most pressing global challenges of the 21st century. Our results suggest that a network approach captures several important aspects of multilateral diplomacy, potentially opening new research avenues to study global health governance. Identifying this network is a first step toward addressing more

analytical questions such as the diffusion of international norms and the 'the dynamic relationship between health being a foreign policy tool and foreign policy serving health goals'.[4] The research priorities are to improve the methodology and to make these data widely available to the scientific and policy communities. The emergence of a standard format for data curation from different multilateral institutions, ideally collected and made available for researchers in an open access public database, would constitute an important development for allowing the full potential of these new research methods to be released. We believe that computational approaches to study multilateral diplomacy, that is, 'computational diplomacy' can provide a new lens to better understand how member states collectively address the most pressing health challenges through global governance.

Twitter Kelley Lee @profplum8

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ORCID iDs
Didier Wernli http://orcid.org/0000-0002-1751-1961
Kelley Lee http://orcid.org/0000-0002-3625-1915

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