Methodological Appendix

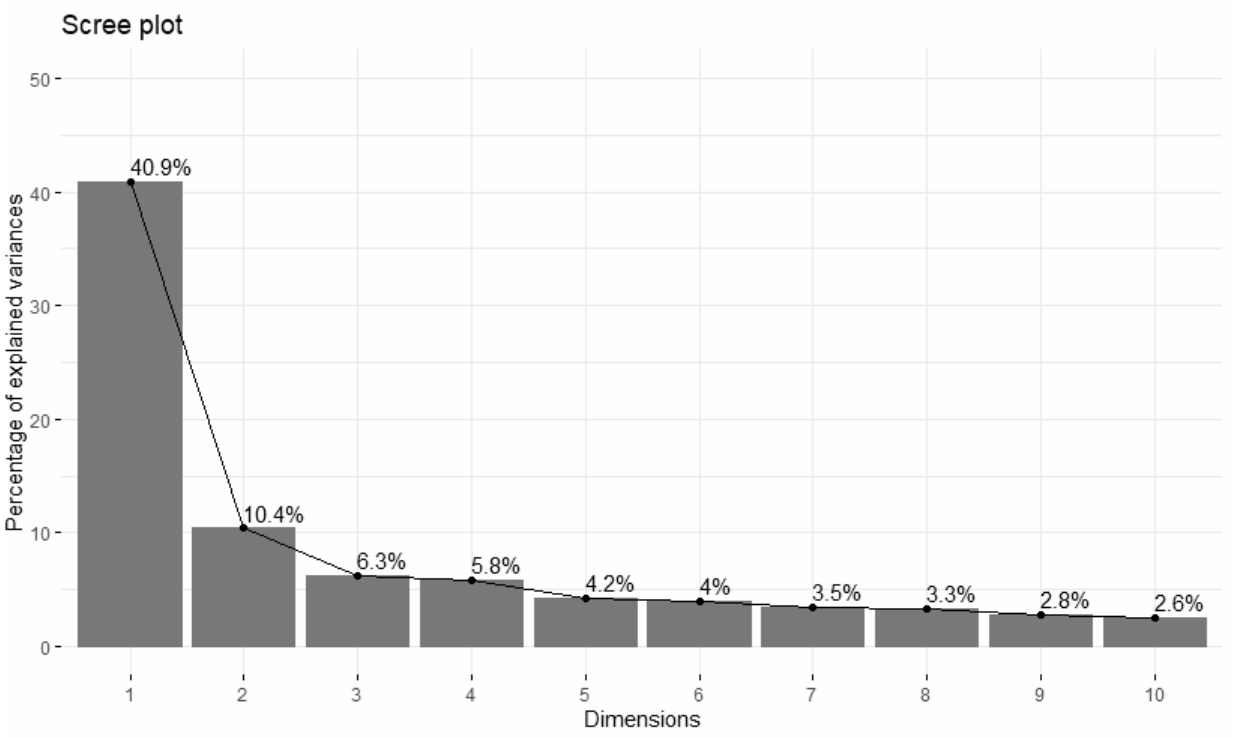
I. Some Notes on PCA

As a descriptive tool, PCA requires no distributional assumptions and can be used on many different kinds of data.[1] Before running PCA, data are scaled and because PCA cannot accommodate missing data, observations with missing data are removed from the dataset. Future work might consider multiple imputation to avoid dropping these observations, which obviously introduces bias into the final result. Our final dataset has 116 countries.

II. Choosing the Number of Components From PCA

A scree plot helps choose how many components to use to represent a given high-dimensional dataset by plotting the eigenvectors recovered from PCA in order of the percentage of variance explained. As shown in the scree plot below, nearly half of the variance in our high-dimensional data is explained by the first component, meaning that there is one major divide within the data, followed by a series of minor divides, the first of which is larger than the others. A scree plot helps discern the number of appropriate components by looking for the "elbow," or the point after which there is a distinct downturn in the predictive power of the component. Below, the elbow occurs at the second component, so these are the two components on which we will focus.

Figure 22A.1. Scree Plot

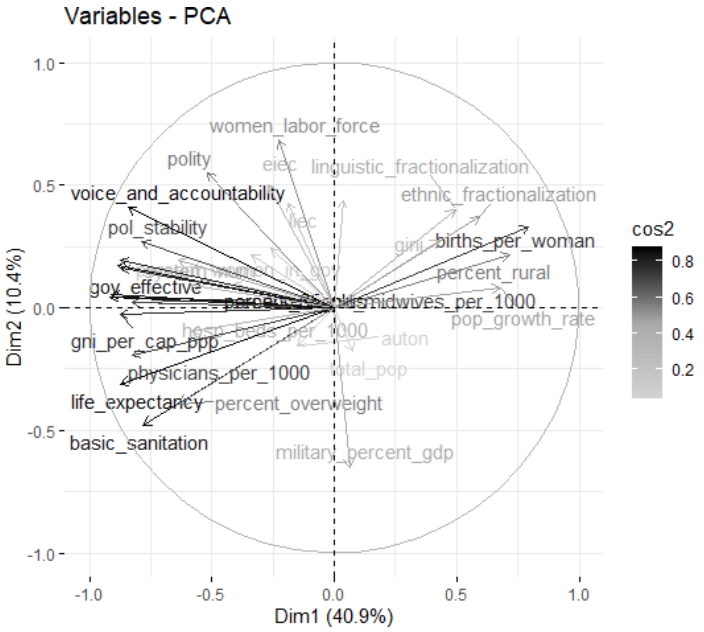


The PCA reveals that our data are described by a primary component accounting for 40.9% of the variance, and a secondary component, accounting for an additional 10.4% of the variance.

[1] Ian T. Jolliffe & Jorge Cadima. Principal Component Analysis: A Review and Recent Developments: Mathematical, Physical and Engineering Sciences, 374 Phil. Transactions Royal Soc. 20150202 (2016).

Combined, these two components explain just over half of all the variance in the dataset. Further components exist, but only account for increasingly small proportions of the variance and are not considered at this time.

Figure 22A.2. Variables Plot



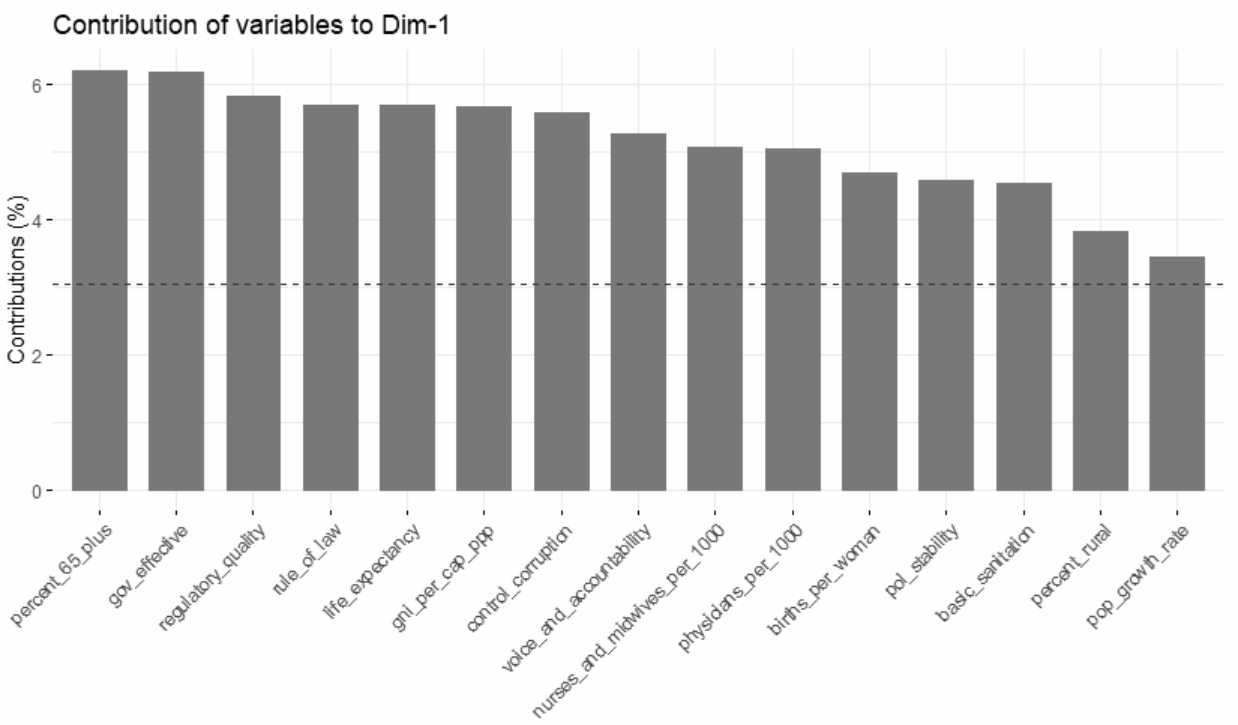
The Variables Plot above shows how our indicators map onto the first two principal components. Positively correlated indicators are grouped together, while negatively correlated indicators are positioned on opposite sides of the origin. The darkness of the arrows indicates the quality of the representation of indicators on the first component as measured by "cos2" (square cosine, squared coordinates). A high cos2, shown in black, indicates a good representation of the variable on the principal component, and these variables are closer to the circumference of the correlation circle. A low cos2, shown in gray, indicates a poor representation of the variable on the first principal component. We learn from this figure that the military spending, factors related to the position of women in society (female employment, percentage of women in government, gender discrimination in employment prohibitions), population size, religious fractionalization, and subnational autonomy of federal units (auton), shown in blue and green, have lower representation on the first component.

A. A Primary Component of "Development"

Countries' scores on the primary component account for 40.9% of the overall variance. Figure 22A.3 shows the indicators that contribute significantly to the primary component. The dotted reference line corresponds to the expected value if each variable's contribution were uniform so the variables in Figure 22A.2 are those that disproportionately contribute to the primary component. It is important to note that variables contribute by predicting each other in linear combination, which can happen through either a positive (e.g., high values on A predict high values on B) or negative (e.g., high values on A predict low values on B) correlation. We see that a significant proportion of variance along the first component is explained by World Bank indicators of **governance**, including government effectiveness, regulatory quality, rule of law, control of corruption, voice and accountability, and political stability. We also see several **health infrastructure indicators**, such as the number of nurses and midwives, and physicians per 1,000 people, and

the percentage of the population with access to basic sanitation. Another set of indices measure **social and cultural** factors, including the percentage of people aged sixty-five and over, fertility rate, population growth rate, percent rural, and life expectancy. A final indicator, gross national income per capita, is an **economic** measure of development.

Figure 22A.3. Contributions of Variables to "Development" Component



Thus, we discern a component that distinguishes between, on the one hand, nations with good governance, high levels of health infrastructure, a more elderly and urban population, with higher income and life expectancy, and, on the other hand, nations with lower indicators of good governance, less health infrastructure, a younger and more rural population, with lower income and life expectancy.

1. Theorizing the "Development Component"

There are strong theoretical reasons to think that our indicator of development would be related to public health. Indicators of governance are significant contributors to this component, and scholars theorize a positive relationship between governance and public health outcomes,[2] though Dizon-Ross et al. argue that governance concerns may be overstated.[3] Pinzon-Rondon et al. find that the rule of law is positively correlated with public health outcomes,[4] while Lewis suggests that voice and accountability "permit communities to be involved in decisions and oversight of health

[2] Maureen Lewis, Governance and Corruption in Public Health Care Systems (Ctr. for Glob. Development Working Paper, No. 78, 2006); Rajaie Batniji et al., Governance and Health in the Arab World, 383 The Lancet 343, 350 (2014); Bingjie Hu & Ronald U. Mendoza, Public Health Spending, Governance and Child Health Outcomes: Revisiting the Links, 14 J. of Hum. Dev. & Capabilities 285, 299 (2013).

[3] Rebecca Dizon-Ross, Pascaline Dupas & Jonathan Robinson, Governance and the Effectiveness of Public Health Subsidies 19 (Nat'l Bureau of Econ. Rsch. Working Paper No. 21324, 2015).

[4] Angela Maria Pinzon-Rondon et al., Association of Rule of Law and Health Outcomes: An Ecological Study, 5 Brit. Med. J. 1, 4 (2015).

care services."[5] However, Kim and Wang do not find a significant effect of voice and accountability on infant mortality, life expectancy, under-five mortality, or maternal mortality after controlling for social, economic, and political health determinants.[6]

Demographic indicators are also prominent in the primary component, with important implications for public health. High fertility rates and lower proportions of people aged sixty-five and older indicate a younger population with fewer health burdens. However, scholars have noticed a negative relationship between fertility rates and the general status of women in societies around the globe,[7] which scholars argue is vital for the public health of society.[8] Life expectancy is one of the most common and widely collected outcomes examined by public health scholars.[9] In a study of ninety-five less-developed countries, Rogers and Wofford found that life expectancy was primarily influenced by socioeconomic development measures such as urbanization but was secondarily influenced by public health measures such as access to safe water, physicians, and adequate nutrition.[10] Ethnic fractionalization is thought to have negative consequences for public health by leading to lower public goods provision.[11]

In addition to governance and demographic features, health infrastructure indicators are significant contributors to the primary component that positively influence health.[12] Finally, as countries grow wealthier, they theoretically have more resources to spend on health. Gross national income per capita (PPP), one of the top contributing indicators to the first component, correlates positively with public health outcomes. Lant Pritchett and Lawrence Summers made the seminal argument that "wealthier nations are healthier nations" and found that a 5% increase in GDP led to an average of a 1% decrease in infant mortality rates.[13]

B. A Secondary Component of "Social Priorities"

The second component, explaining 10.4% of the variation in the data, is characterized by political distinctions that, in linear combination, explain variation orthogonal to (independent of) the first component. We describe the second component as a measure of "social priorities." As

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[5] Lewis, supra note 2, at 7.

[6] Sunhee Kim & Jaesun Wang, Does Quality of Government Matter in Public Health?: Comparing the Role of Quality and Quantity of Government at the National Level, 11 Sustainability 3229, 3239 (2019).

[7] Mizanur Rahman & Julie DaVanzo, Gender Preference and Birth Spacing in Matlab, Bangladesh, 30 Demography 315, 329 (1993); Anju Malhotra, Reeve Vanneman & Sunita Kishor, Fertility, Dimensions of Patriarchy, and Development in India, 21 Population and Dev. R. 281, 299 (1995); Julie Cwikel, Rachel Lev-Wiesel & Alean Al- Krenawi, The Physical and Psychosocial Health of Bedouin Arab Women of the Negev Area of Israel: The Impact of High Fertility and Pervasive Domestic Violence, 9 Violence Against Women 240, 250 (2003).

[8] Daniel J. Kruger, Maryanne L. Fisher & Paula Wright, Patriarchy, Male Competition, and Excess Male Mortality, 8 Evolutionary Behavioral Sci. 3, 8 (2014).

[9] Karin Modig, Roland Rau & Anders Ahlbom, Life Expectancy: What Does it Measure?, 10 Brit. Med. J. 1 (2020).

[10] Richard G. Rogers & Sharon Wofford, Life Expectancy in Less Developed Countries: Socioeconomic Development or Public Health?, 21 J. of Biosocial Sci. 245, 245 (1989).

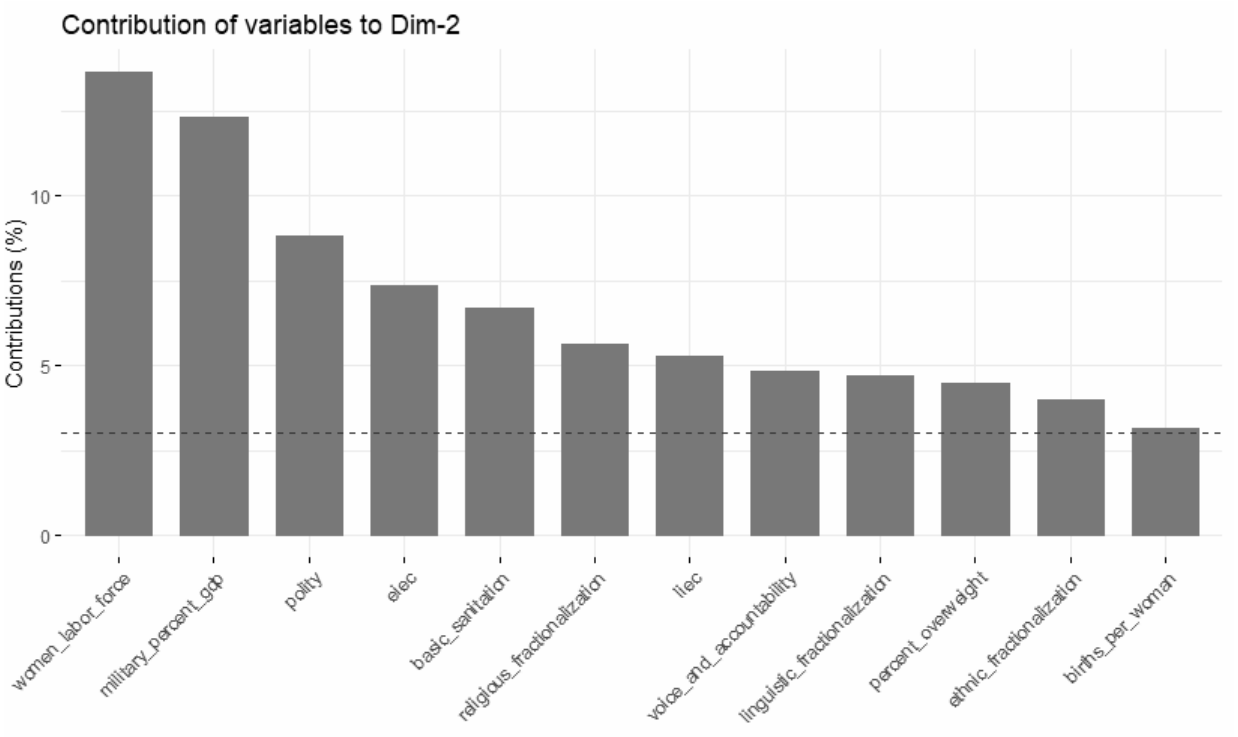
[11] Alberto Alesina, Reza Baqir & William Easterly, Public Goods and Ethnic Divisions, 114 Q. J. Econ. 1243, 1244 (1999); Hazem Adam Ghobarah, Paul Huth & Bruce Russett, Comparative Public Health: The Political Economy of Human Misery and Well-Being, 48 Int'l Studies Q. 73, 88 (2004); Sefa Awaworyi Churchill, Janet Exornam Ocloo & Diana Siawor-Robertson, Ethnic Diversity and Health Outcomes, 134 Soc. Indicators Res. 1077, 1096 (2017); Johan P. Mackenbach & Martin McKee, A Comparative Analysis of Health Policy Performance in 43 European Countries, 23 Eur. J. Pub. Health 195, 198 (2013).

[12] Jane Robinson & Heather Wharrad, Invisible Nursing: Exploring Health Outcomes at a Global Level. Relationships Between Infant and Under-5 Mortality Rates and the Distribution of Health Professionals, GNP per Capita, and Female Literacy, 32 J. of Advanced Nursing 28, 36 (2000); James Macinko, Barbara Starfield & Leiyu Shi, Quantifying the Health Benefits of Primary Care Physician Supply in the United States, 37 Int'l J. of Health Serv. 111, 123 (2007).

[13] Lant Pritchett & Lawrence H. Summers, Wealthier is Healthier 1150 (1993).

shown in Figure 22A.4, the indicator that makes the most considerable contribution to the second component is the rate of *female labor force participation*, reflecting the **status of women**. *Fertility rate* is another women-related variable, but it is the lowest of the above-average contributors. Next, several **political** indicators, including the percentage of gross domestic product spent on the *military*, *democracy* (polity), World Bank indices of *executive* and *legislative electoral competitiveness* (EIEC and LIEC), and the World Governance Indicator for *voice and accountability*. Additionally, we see **social and cultural** indicators such as *religious*, *linguistic*, and *ethnic fractionalization*, and two indicators of **health** in access to *basic sanitation* and *percent overweight*. As in Figure 22A.3, the dotted line indicates the level at which variables would be proportionately contributing to the second component.

Figure 22A.4. Contributions of Variables to "Social Priorities" Component



1. Theorizing the "Social Priorities Component"

The fact that a component characterized by women's position in society, military spending, and democracy emerges as orthogonal to the primary "development component" is indicative of a broader pattern observed in the comparative international development literature: democracy and good governance are not necessarily the same thing.[14] Looking at Figure 1 in this chapter, we can see that governance (most prominently part of the first component on the x-axis) and democracy (part of the second component on the y-axis) overlap for some countries such as Switzerland. In contrast, others like China, Jordan, and the United Arab Emirates, which score lower on democracy but in the middle on governance, pull away towards the bottom center of Figure 1.

[14] Bo Rothstein, The Quality of Government: Corruption, Social Trust, and Inequality in International Perspective 26 (2011).

In addition to displaying governance without democracy, the "social priorities" component also contains indicators of women's participation in labor markets and military spending. Female labor force participation is positively related to public health outcomes. Looking within the United States, Kawachi et al. find that the percentage of women in the labor force at the state level correlates negatively with mortality rates for both men and women and the average number of days of activity limitation.[15]

Countries with low scores on the "social priorities" component also exhibit higher military spending levels as a percentage of their GDPs. Military spending may affect public health outcomes in multiple ways. Following a "guns versus butter" logic,[16] some scholars find that military spending "crowds out" social spending, such as spending on health.[17] Additionally, Gupta et al. find that higher military spending is associated with higher corruption, which would theoretically negatively affect health outcomes through the governance channel discussed above.[18] Alternatively, looking at thirty-one OECD countries between 1980 and 2010, Reeves and Stuckler find little evidence that military spending crowds out public health spending and instead find that military and health spending are positively and significantly correlated for this group.[19]

Finally, ethnic, linguistic, and religious fractionalization are also higher for countries with lower scores on the "social priorities" component. Churchill et al. find that both ethnic and linguistic heterogeneity are associated with lower childhood immunization rates.[20] Many studies collapse ethnic and linguistic fractionalization into an ethnolinguistic fractionalization index.

These studies also generally find adverse effects on health outcomes.[21] In contrast to ethnic fractionalization, higher religious fractionalization may reflect a more tolerant society rather than a more divided one,[22] especially if other forms of unity are present.[23] In a study of government policy responses to HIV/AIDS, Lieberman finds adverse effects of ethnic fractionalization on AIDS policy, but no such relationship for religious fractionalization.[24]

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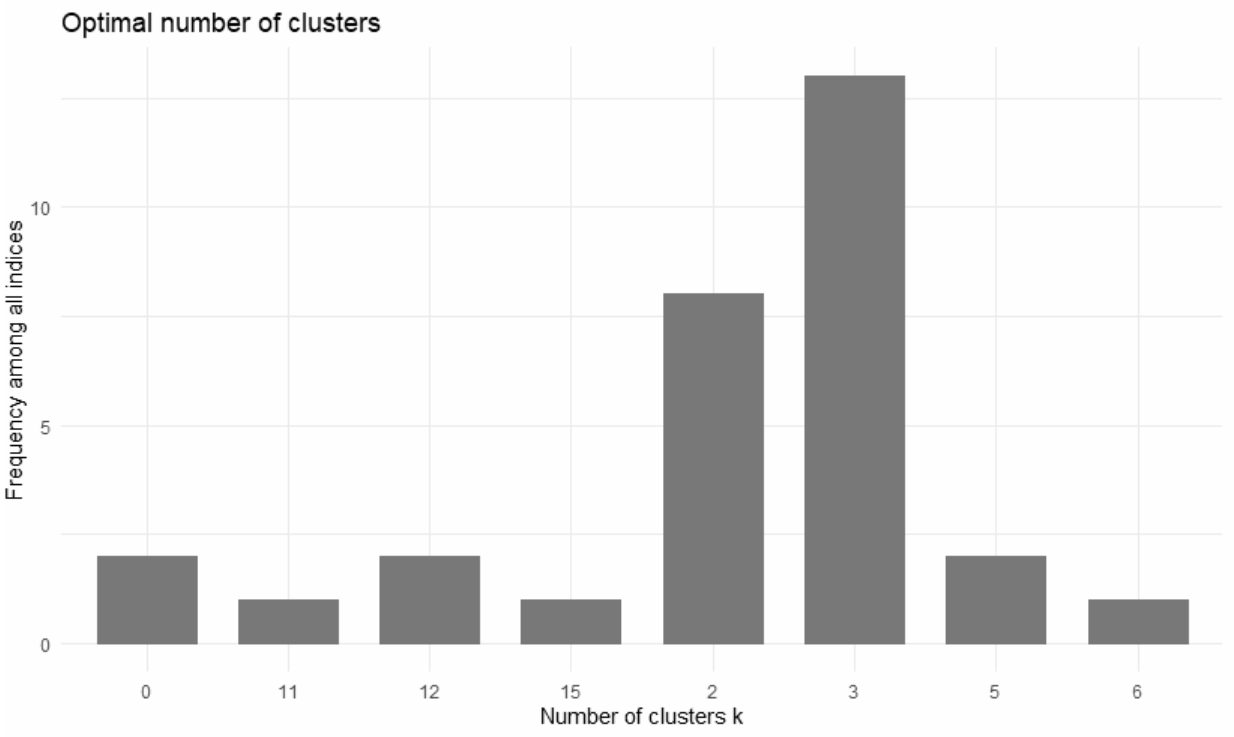
[15] Ichiro Kawachi et al., Women's Status and the Health of Women and Men: A View from the States, 48 Soc. Sci & Med. 21, 28 (1999).
[16] Bruce M. Russett, Who Pays for Defense?, 63 Am. Pol. Sci. Rev. 412, 417 (1969).
[17] HongLi Fan, Wei Liu & Peter C. Coyte, Do Military Expenditures Crowd-Out Health Expenditures? Evidence from Around the World, 2000–2013, 29 Def. and Peace Econ. 766, 777 (2018).
[18] Sanjeev Gupta, Marijn Verhoeven & Erwin R. Tiongson, The Effectiveness of Government Spending on Education and Health Care in Developing and Transition Economies, 18 Eur. J. Pol. Econ. 717 (2002).
[19] Aaron Reeves & David Stuckler, Crowd-Out of Defence and Health Spending: Is Israel Different from Other Industrialised Nations?, 2 Israel J. Health Pol'y Res. 1, 2 (2013).
[20] Sefa Awaworyi Churchill, Janet Exornam Ocloo & Diana Siawor-Robertson, Ethnic Diversity and Health Outcomes, 137 Soc. Indicators Rsch. 1077, 1096 (2017).
[21] John C. Anyanwu & Andrew EO Erhijakpor, Health Expenditures and Health Outcomes in Africa, 21 Afr. Dev Rev. 400 (2009); Klaus Desmet, Joseph Flavian Gomes & Ignacio Ortuño-Ortín, The Geography of Linguistic Diversity and the Provision of Public Goods, 143 J. Dev. Econ. 102384 (2020).
[22] See supra note 11.
[23] Prerna Singh, We-ness and Welfare: A Longitudinal Analysis of Social Development in Kerala, India, 39 World Dev. 282, 290 (2011).
[24] Evan Lieberman, Boundaries of Contagion: How Ethnic Politics Have Shaped Government Responses to AIDS (2009).

Figure 22A.5. Choosing the Optimal Number of Clusters for k-means



Choosing the optimal number of clusters for k-means analysis is a combination of art and science. We run the NbClust function from the NbClust package in R, which provides thirty indices for determining the number of clusters. Although three clusters is the most commonly suggested number, we decided to use five clusters, as suggested by the SD and S_Dbw indices.[25] A 2010 study found that S_Dbw was the only internal validation measure that performed well in every area they tested: monotonicity, noise, density, subclusters, and skewed distributions.[26] While a three-cluster model is suggested by more metrics, we find that the five-cluster model allows us to say more interesting things about the individual groups and has a good level of face validity.

II. Measuring Government Containment

In addition to examining the average government containment, we also examine the relationship between the speed of spread and the maximum value of a country's government containment score, shown in the graph below. This should help account for the variation in the severity of the pandemic, assuming that countries draw on maximum containment measures in response to acute conditions.

[25] Maria Halkidi, Michalis Vazirgiannis & Yannis Batistakism, Quality Scheme Assessment in the Clustering Process, Eur. Conf. on Principles of Data Mining and Knowledge Discovery 265 (2000).
[26] Yanchi Liu et al., Understanding of Internal Clustering Validation Measures, 2010 Inst. of Elec. & Elecs. Eng'rs Int'l Conf. on Data Mining 911 (2010).

Figure 22A.6. Average Government Containment vs. Speed of Spread