Online Appendices

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Appendix 1. Study Data and Methodology

Table 1. Data used to form the healthcare system financing types

Country	Current health expenditure per capita in US$, PPP (CHE)[a]	Domestic general government health expenditure, % of CHE[a]	Private household out-of-pocket expenditure, % of CHE[a]
Australia	5,004.9	69.1	17.7
Austria	5,879.1	73.1	18.4
Belgium	5,404.9	75.8	19.1
Brazil	1,530.8	41.7	27.5
Canada	5,200.0	73.5	14.7
Chile	2,305.7	50.8	33.2
China	935.2	56.4	35.8
Colombia	1,155.4	71.6	15.1
Costa Rica	1,336.5	72.4	22.4
Czechia	3,040.5	82.7	14.2
Denmark	5,794.3	83.8	13.8
Estonia	2,427.6	73.6	24.7
Finland	4,457.2	78.6	18.4
France	5,250.5	73.4	9.3
Germany	6,098.2	77.7	12.7
Greece	2,340.2	51.9	36.4

Hungary	2,115.2	69.1	26.9
Iceland	5,113.2	82.4	16.0
Indonesia	375.2	49.3	34.9
Ireland	5,896.7	73.9	12.1
Israel	3,207.5	64.7	21.1
Italy	3,624.1	73.9	23.6
Japan	4,503.7	84.1	12.8
Latvia	1,895.8	59.7	39.3
Lithuania	2,313.0	65.9	31.6
Luxembourg	6,047.8	84.9	10.5
Mexico	1,066.0	50.1	42.1
Netherlands	5,634.5	64.9	10.8
New Zealand	4,024.4	74.8	12.9
Norway	6,818.4	85.3	14.3
Poland	2,015.3	71.1	20.8
Portugal	3,242.4	61.5	29.5
Russia	1,488.3	59.5	38.3
Slovakia	2,179.5	79.2	18.9
Slovenia	3,158.4	72.4	12.0
South Africa	1,129.4	54.1	7.7
South Korea	3,213.7	58.5	32.5
Spain	3,576.5	70.4	22.2
Sweden	5,828.4	85.1	13.8
Switzerland	8,113.9	31.2	28.0
Turkey	1,170.8	77.4	17.5
United Kingdom	4,619.6	78.6	16.7
United States	10,623.9	50.4	10.8

Sources: WHO (2020), notes: a = observations from the year 2018

Table 2. Data used to form the healthcare system provision types

Country	Gatekeeping[a]	Primary health care delivery[a]	Medical doctors, per 10,000 population[a]	Hospital beds, per 10,000 population[a]	UHC index for service coverage[e]
Australia	2.0	1.0	37.6	38.4 [c]	83.00
Austria	3.0	1.0	52.1	72.7	81.60
Belgium	2.0	1.0	31.2	56.2	81.40
Brazil	1.0	2.0	21.7[b]	20.9 [b]	75.90
Canada	1.0	1.0	24.5	25.5	82.20
Chile	1.0	2.0	51.8	20.6	80.70
China	3.0	2.0	19.8 [b]	43.1 [b]	77.40
Colombia	1.0	3.0	38.4	17.1	79.30
Costa Rica	1.0	2.0	28.9	11.1	80.80
Czechia	3.0	1.0	40.2	66.2	79.10
Denmark	1.0	1.0	42.3	24.3	81.30
Estonia	2.0	1.0	34.6 [b]	45.7	78.90
Finland	1.0	2.0	46.4	36.1	81.60
France	2.0	1.0	65.3	59.1	82.50
Germany	2.0	1.0	43.0	80.0 [b]	81.70
Greece	3.0	2.0	62.3	42.0	81.10
Hungary	2.0	1.0	34.1	70.1	76.40
Iceland	3.0	3.0	40.8	28.7	82.30
Indonesia	2.0	2.0	4.3	10.4 [b]	71.30
Ireland	2.0	1.0	33.1	29.7	81.80
Israel	2.0	3.0	69.4	29.8	82.60
Italy	1.0	3.0	79.3	31.4	83.00
Japan	3.0	1.0	24.8	129.8	84.30
Latvia	1.0	1.0	33.0	54.9	75.40

Lithuania	1.0	2.0	63.5	64.3	76.00
Luxembourg	3.0	1.0	30.1 [b]	45.1	82.40
Mexico	1.0	3.0	48.5	9.8	76.00
Netherlands	1.0	1.0	37.1	31.7	81.80
New Zealand	1.0	1.0	34.2	26.2	82.00
Norway	1.0	1.0	47.8	35.3	82.60
Poland	1.0	1.0	23.8 [b]	65.4	78.30
Portugal	2.0	2.0	53.1	34.5	81.60
Russia	3.0	3.0	44.4	71.2	73.20
Slovakia	1.0	1.0	35.2	57.0	78.20
Slovenia	1.0	2.0	31.7	44.3	81.30
South Africa	2.0	2.0	7.9	23.0 [d]	65.30
South Korea	3.0	1.0	24.1	124.3	83.30
Spain	1.0	3.0	40.3	29.7	83.20
Sweden	3.0	2.0	43.3 [b]	21.4	82.40
Switzerland	2.0	1.0	43.3	46.3	83.40
Turkey	3.0	2.0	18.1	28.5	78.60
United Kingdom	1.0	1.0	56.2	25.0	81.40
United States	3.0	2.0	26.0	28.7 [b]	78.50

Sources: WHO (2020); Country HiTs (European Observatory on Health Systems and Policies, n.d., The Asia Pacific Observatory on Health Systems and Policies, n.d.); Lorenzoni et al. (2019); Paris et al. 2010; WHO (2017), notes: Gatekeeping: strong = 1 (compulsory), moderate = 2 (financially encouraged/partial gatekeeping), low = 3 (no obligation and no incentive); Primary health care: mainly private = 1 (private clinics/group/solo practices), mixed = 2, mainly public = 3 (public centres or solo practices); a = observations from the years 2006-2020 (see details in Table 4 below); b = observations from the year 2017; c = observations from the year 2016; d = observations from the year 2010; e = observations from the year2017 (a population-weighted average of UHC service coverage index values across countries)

Data collection methods

We wanted to maximize data comparability and collected data from year 2018 because most observations were available for 2018. HiTs' and other sources' publication years ranged from 2006 to 2020, even though most of them were published after 2010. If two or more HiTs of a same country were available, we based the estimates on the source that was published closest to 2018. If a country HiT was published before year 2010, the information was checked from the OECD working paper on health systems of its member countries (Paris et al. 2010).

Medical doctors

The indicator of medical doctors includes general and specialist medical practitioners, medical doctors without further definition, and only practising or all registered medical doctors depending on the country specific data source (WHO, 2020). Specialized and primary care physician services are defined in a similar way in every country using the same the ISCO -08 codes (WHO, 2020).

UHC index

UHC essential service coverage index includes measures of hospital bed and physician densities which are also included separately as indicators of health service provision in our analysis. However, the aim of the UHC index is to measure average coverage of essential services, and hospital bed and physician densities indicators were rescaled against a maximum threshold so that the measures would reflect low coverage rates. Also, the different types of medical doctors were given their own threshold (the maximum threshold for hospital beds was set to 18 per 10,000, physician density 9 per 10,000, psychiatrists 0.1 per 10,000, and surgeons 1.4 per 10,000 population) after which the values were combined to form a health worker density indicator (Hogan et al. 2018). Our indicator of medical doctor density does not separate or weigh types of medical doctors differently. Furthermore, we have not set thresholds for hospital bed and medical doctor densities which makes it possible to measure overcapacity or overuse of health services. Most countries in our analyses exceed the maximum thresholds which means the UHC index does not distinguish service coverage in these countries.

Gatekeeping

For each of the health systems, we considered which of the ways access to specialized care describes the degree of regulation in patients' access to care the most accurately (Paris et al., 2010; European Observatory on Health Systems and Policies, n.d.; Lorenzoni et al., 2019; Asia Pacific Observatory on Health Systems and Policies, n.d.; WHO 2017).

European Observatory on Health Systems and Policies (n.d.) & The Asia Pacific Observatory on Health Systems and Policies (n.d): HiT health system reviews (HiTs) are country-based reports that provide a detailed description of each health care system and of reform and policy initiatives in progress or under development. Each review is produced by country experts in collaboration with the Observatory's research directors and staff. In order to facilitate comparisons between countries, the reports are based on a template, which is revised periodically.

WHO gatekeeper definition: a health care provider at the first contact level who has responsibilities for the provision of primary care as well as for the coordination of specialized care and referral (https://www.who.int/healthsystems/hss_glossary/en/index5.html).

Template for Health Systems in Transition-Authors (https://www.euro.who.int/__data/assets/pdf_file/0009/393498/HiT-template-for-web-for-authors-2019.pdf?ua=1): Provision of services. Describe the level of choice and access to primary care. Relevant issues might include: freedom of choice of primary care physicians (for example, GPs) and any restrictions with respect to changing physicians, whether patients have direct access to specialist (ambulatory and hospital) services, whether the GP has a gatekeeping role, the role of GPs in coordinating care, the referral process.

Lorenzoni et al. (2019): The country experts filled in the OECD survey questionnaire. The survey was done using a survey data tool to gather responses which consisted of an Excel file that contained several sheets, each corresponding to one section of the survey. Drop-down multiple-choice menus facilitate the task of providing responses to questions. Guidelines for data collection and a glossary were prepared too. The data survey tool was made available to countries in English and Spanish.

Survey question to investigate secondary care related gatekeeping was: Do primary care physicians control access to specialist care? The response options were: A. There is no need and no incentive to obtain primary care physician referral and B. Primary care physician referral is compulsory to access most types of specialist care (except in case of emergency).

Paris et al. (2010): The country experts filled in the OECD survey questionnaire. A survey was designed to collect qualitative information on health coverage, health care provision, resource allocation and governance. The questionnaire included about 80 questions, often with multiple items and sub-questions for further details. The survey data was collected as a online survey in 2008.

Survey question to investigate secondary care related gatekeeping was: Do primary care physicians control access to outpatient specialist care? The response options were: A. Primary care physician referral is compulsory to access most types of specialist care (compulsory), B. Patients have financial incentives to obtain a primary care physicians' referral (e.g. reduced copayments), but direct access is always possible (financially encouraged), and C. There is no need and no incentive to obtain primary care physician referral (no obligation and no incentive).

WHO (2017): Country experts have written the report which was guided by a template for the case study provided by the Alliance for Health Policy and Systems Research. A team of country experts sourced and reviewed a wide range of available documentation and consulted with 29

key players (national government policy-makers, provincial, district and programme managers, statutory bodies, nongovernmental organizations and technical agencies providing support to government and higher educational institutions) in the field who provided further insights and information.

Primary health care delivery

For each of the health systems, we considered which delivery type describes the primary healthcare service delivery the most accurately (Paris et al., 2010; European Observatory on Health Systems and Policies, n.d.; Lorenzoni et al., 2019; Asia Pacific Observatory on Health Systems and Policies, n.d.; WHO 2017).

European Observatory on Health Systems and Policies (n.d.) & The Asia Pacific Observatory on Health Systems and Policies (n.d): HiT health system reviews (HiTs) are country-based reports that provide a detailed description of each health care system and of reform and policy initiatives in progress or under development. Each review is produced by country experts in collaboration with the Observatory's research directors and staff. In order to facilitate comparisons between countries, the reports are based on a template, which is revised periodically.

Template for Health Systems in Transition-Authors (https://www.euro.who.int/__data/assets/pdf_file/0009/393498/HiT-template-for-web-for-authors-2019.pdf?ua=1): Provision of services, Primary care: Describe the organization and provision of primary care services, including settings, responsible organizations, nature of providers and functions. Relevant issues might include: settings and models of provision: independent/single practices, group practice, health centres, medical laboratories, hospitals, polyclinics, whether primary care providers are directly employed or contracted.

In the template, primary care was defined: Primary care refers to the individual's first point of contact with the health system and includes general medical care for common conditions and injuries. Primary care may include the following services: general medical care, diagnostic services, minor surgery, rehabilitation, family planning, obstetric care, perinatal care, first aid, dispensing of pharmaceutical prescriptions, certification, 24-hour availability, home visits, nursing care for acute and chronic illnesses, palliative care, specific services for mental illness, preventive services (for example, immunization, screening) and health promotion services (for example, health education).

Lorenzoni et al. (2019): The country experts filled in the OECD survey questionnaire. The survey was done using a survey data tool to gather responses which consisted of an Excel file that contained several sheets, each corresponding to one section of the survey. Drop-down multiple-choice menus facilitate the task of providing responses to questions. Guidelines for data collection and a glossary were prepared too. The data survey tool was made available to countries in English and Spanish.

Survey questions to investigate primary care service provision were: 1. Are primary care services provided predominantly in? The response options were: A. Public primary care clinics staffed by physicians and other health professionals (e.g., nurses), and B. Other, specify. 2. Is there a second significant form of service provision? The response options were: A. Outpatient departments of private hospitals, B. Outpatient departments of public hospitals, C. Outpatient departments of public and private hospitals, and D. Private group practices.

Paris et al. (2010): The country experts filled in the OECD survey questionnaire. A survey was designed to collect qualitative information on health coverage, health care provision, resource allocation and governance. The questionnaire included about 80 questions, often with multiple items and sub-questions for further details. The survey data was collected as a online survey in 2008.

Survey questions to investigate primary care service provision were: 1. Are primary care services provided predominately in: A. private clinics/health care centres, B. private group practices, C. private solo practice, and D. other. 2. If there a second significant form of service provision (providing more than 20% of primary care services), please specify (using categories mentioned above).

WHO (2017): Country experts have written the report which was guided by a template for the case study provided by the Alliance for Health Policy and Systems Research. A team of country experts sourced and reviewed a wide range of available documentation and consulted with 29 key players (national government policy-makers, provincial, district and programme managers, statutory bodies, nongovernmental organizations and technical agencies providing support to government and higher educational institutions) in the field who provided further insights and information.

Table 3. Data used to form the healthcare system outcome types

Country	Measles-containing-vaccine first-dose immunization coverage among 1-year-olds (%)[a]	Maternal mortality ratio, per 100,000 live births[b]	Age-standardized cancer death rates (15+), per 100,000 population[c]	Difference in life expectancy at birth in years between males and females[d]	Life expectancy at birth both sexes[d]
Australia	95.0	6.0	289.1	3.5	83.00
Austria	94.0	5.0	307.8	4.4	81.60
Belgium	96.0	5.0	333.8	4.2	81.40
Brazil	92.0	60.0	299.3	7.0	75.90
Canada	90.0	10.0	303.4	3.7	82.20
Chile	93.0	13.0	330.8	5.1	80.70
China	99.0	29.0	366.4	5.8	77.40
Colombia	95.0	83.0	327.4	5.2	79.30
Costa Rica	94.0	27.0	286.0	5.1	80.80
Czechia	96.0	3.0	368.1	5.6	79.10
Denmark	95.0	4.0	374.8	3.4	81.30
Estonia	87.0	9.0	423.4	7.9	78.90
Finland	96.0	3.0	273.6	4.8	81.60
France	90.0	8.0	345.4	5.3	82.50
Germany	97.0	7.0	329.9	6.1	81.70
Greece	97.0	3.0	337.1	5.0	81.10
Hungary	99.0	12.0	501.8	6.5	76.40
Iceland	93.0	4.0	316.6	3.1	82.30
Indonesia	89.0	177.0	307.4	3.9	71.30
Ireland	92.0	5.0	336.3	3.3	81.80
Israel	98.0	3.0	302.2	3.6	82.60
Italy	93.0	2.0	312.2	4.0	83.00

Japan	97.0	5.0	288.8	5.4	84.30
Latvia	98.0	19.0	435.0	9.2	75.40
Lithuania	92.0	8.0	417.1	9.2	76.00
Luxembourg	99.0	5.0	314.3	3.6	82.40
Mexico	97.0	33.0	193.9	5.8	76.00
Netherlands	93.0	5.0	374.1	2.7	81.80
New Zealand	92.0	9.0	309.4	3.1	82.00
Norway	96.0	2.0	310.2	3.0	82.60
Poland	93.0	2.0	435.2	7.4	78.30
Portugal	99.0	8.0	336.1	5.8	81.60
Russia	98.0	17.0	451.5	9.8	73.20
Slovakia	96.0	5.0	461.7	6.6	78.20
Slovenia	93.0	7.0	398.4	5.5	81.30
South Africa	70.0	119.0	366.8	6.1	65.30
South Korea	98.0	11.0	295.2	5.8	83.30
Spain	97.0	4.0	300.8	5.0	83.20
Sweden	97.0	4.0	289.1	3.2	82.40
Switzerland	95.0	5.0	282.7	3.3	83.40
Turkey	96.0	17.0	367.1	4.3	78.60
United Kingdom	92.0	7.0	332.8	3.2	81.40
United States	92.0	19.0	312.2	4.4	78.50

Sources: WHO (2020); a = observations from the year 2018; b = observations from the year 2017; c = observations from the year 2016; d = observations from the year 2019

Data collection methods:

Measles-vaccine coverage among 1-year-olds

Even though the UHC index includes a measure of child immunization rate (1-year-olds who have received three doses of a diphtheria, tetanus, and pertussis vaccine), the measure of measles-vaccine coverage among 1-year-olds used in our analysis is intended to indicate health system performance, not to measure health service coverage as in the UHC index. In the context of cluster analysis, including similar variables that represent the same concept, may lead to a higher weight of one concept over others which in turn might influence the cluster formation (Everitt et al. 2015, 63-67). In the case of measles-vaccine coverage and child immunization rate, if they were both included in the analysis as individual variables, their high correlation with each other would mean they measure similar concept and using both might give the concept of quality of child healthcare higher weight compared to the other variables. However, because child immunization rate is included in the UHC index, UHC index and measles-vaccine coverage correlate weakly, and thus, measure different concepts: quality of child healthcare and coverage of essential health services.

Age-standardized cancer death rates

For the indicator, we have combined the deaths rates of males and females. While cancer mortality could be assessed in relation to cancer incidence, the WHO or the OECD statistics do not contain up-to-date data, or they have no data on cancer incidence which is the reason why cancer mortality indicator enables better comparability between the different countries at the moment. Furthermore, it could be said that cancer mortality measures the overall performance of health systems in providing cancer care, not just the performance of specialised care (Bonaventure et al. 2018). However, many countries have concentrated resources (e.g. cancer care beds) and expertise (e.g. specialist staff) on cancer care at specialised institutions (OECD, 2013), which effectively indicates secondary care performance of health systems. This measure also captures regional inequalities in cancer survival around the world, and best survival rates are in wealthy economies such as in the Nordic countries, North America, Australia, and New Zealand (Bonaventure et al. 2018).

Table 4. Publication years of HiTs and other supporting documents

Country	Document type	Publication year
Australia	Health system review, European Observatory on Health Systems and Policies; Health Systems Institutional Characteristics. A Survey of 29 OECD Countries, OECD	2006; 2010
Austria	Health system review, European Observatory on Health Systems and Policies	2018
Belgium	Health system review, European Observatory on Health Systems and Policies	2020
Brazil	Health systems characteristics: A survey of 21 Latin American and Caribbean countries, OECD	2019
Canada	Health system review, European Observatory on Health Systems and Policies	2020
Chile	Health systems characteristics: A survey of 21 Latin American and Caribbean countries, OECD	2019
China	Health system review, Asia Pacific Observatory on Health Systems and Policies	2015
Colombia	Health systems characteristics: A survey of 21 Latin American and Caribbean countries, OECD	2019
Costa Rica	Health systems characteristics: A survey of 21 Latin American and Caribbean countries, OECD	2019
Czechia	Health system review, European Observatory on Health Systems and Policies	2015
Denmark	Health system review, European Observatory on Health Systems and Policies	2012
Estonia	Health system review, European Observatory on Health Systems and Policies	2018
Finland	Health system review, European Observatory on Health Systems and Policies	2019
France	Health system review, European Observatory on Health Systems and Policies	2015
Germany	Health system review, European Observatory on Health Systems and Policies	2014
Greece	Health system review, European Observatory on Health Systems and Policies	2017
Hungary	Health system review, European Observatory on Health Systems and Policies	2011
Iceland	Health system review, European Observatory on Health Systems and Policies	2014
Indonesia	Health system review, Asia Pacific Observatory on Health Systems and Policies	2017
Ireland	Health system review, European Observatory on Health Systems and Policies; Health Systems Institutional Characteristics. A Survey of 29 OECD Countries, OECD	2009; 2010
Israel	Health system review, European Observatory on Health Systems and Policies	2015
Italy	Health system review, European Observatory on Health Systems and Policies	2014
Japan	Health system review, Asia Pacific Observatory on Health Systems and Policies	2018

Latvia	Health system review, European Observatory on Health Systems and Policies	2019
Lithuania	Health system review, European Observatory on Health Systems and Policies	2013
Luxembourg	Health system review in brief, European Observatory on Health Systems and Policies	2015
Mexico	Health systems characteristics: A survey of 21 Latin American and Caribbean countries, OECD Health system review, European Observatory on Health Systems and Policies	2019; 2020
Netherlands	Health system review, European Observatory on Health Systems and Policies	2016
New Zealand	Health system review, Asia Pacific Observatory on Health Systems and Policies	2014
Norway	Health system review, European Observatory on Health Systems and Policies	2020
Poland	Health system review, European Observatory on Health Systems and Policies	2019
Portugal	Health system review, European Observatory on Health Systems and Policies	2017
Russia	Health system review, European Observatory on Health Systems and Policies	2011
Slovakia	Health system review, European Observatory on Health Systems and Policies	2016
Slovenia	Health system review, European Observatory on Health Systems and Policies	2016
South Africa	Primary Health Care Systems (PRIMASYS), World Health Organization	2017
South Korea	Health system review, Asia Pacific Observatory on Health Systems and Policies	2015
Spain	Health system review, European Observatory on Health Systems and Policies	2018
Sweden	Health system review, European Observatory on Health Systems and Policies	2012
Switzerland	Health system review, European Observatory on Health Systems and Policies	2015
Turkey	Health system review, European Observatory on Health Systems and Policies	2011
United Kingdom	Health system review, European Observatory on Health Systems and Policies	2015
United States	Health system review, European Observatory on Health Systems and Policies	2020

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Bonaventure, A., Stiller, C. A., Monnereau, A., Hamdi-Chérif, M., Somdyala, N. I. M., Espinola, S. B., . . . Lewis, C. (2018). Global surveillance of trends in cancer survival 2000–14 (CONCORD-3): Analysis of individual records for 37 513 025 patients diagnosed with one of 18 cancers from 322 population-based registries in 71 countries. *Lancet, 391*(10125), 1023-1075. https://doi.org/10.1016/S0140-6736(17)33326-3

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Appendix 2. Variable correlations, clustering with average linkage method and k-means, and the results of elbow method and Calinski-Harabasz index

Variable correlations

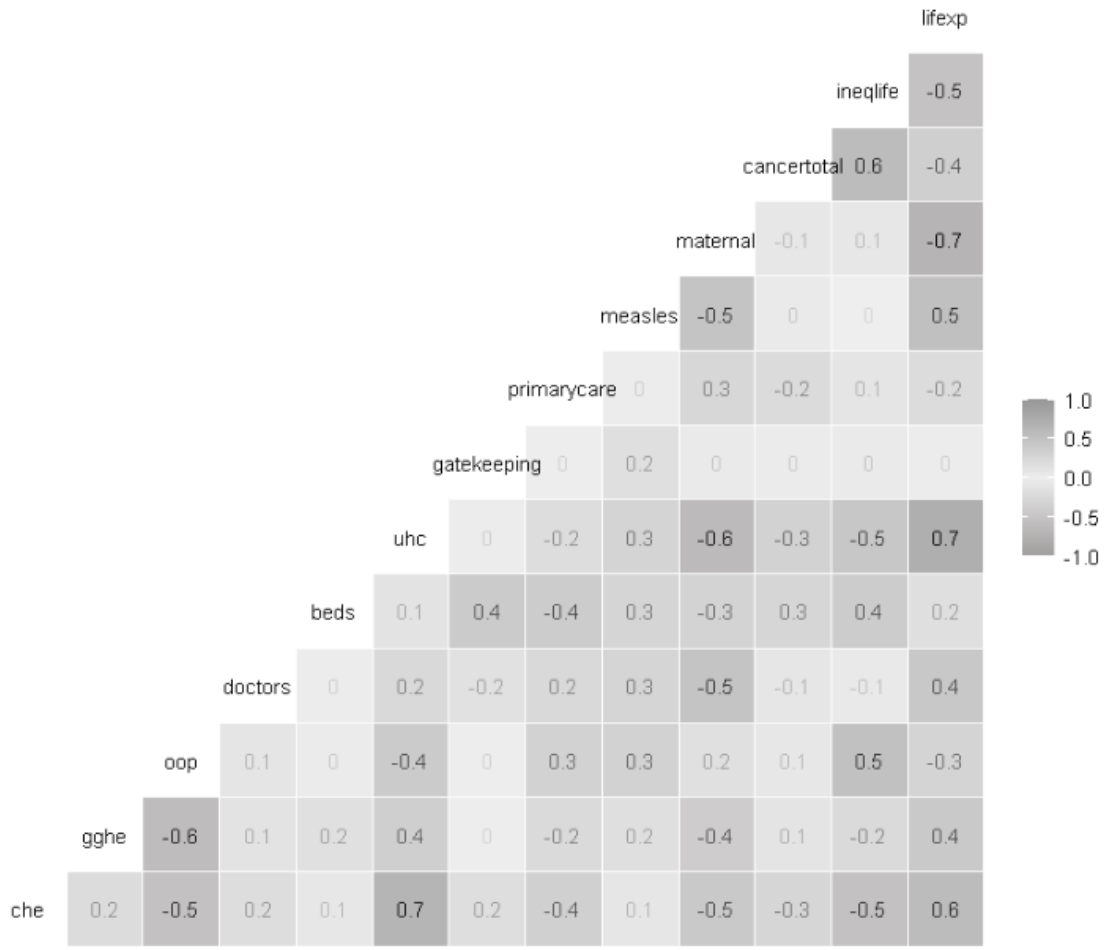

Figure 1. Variable correlations for all variables in the data

Results of cluster validation methods

The elbow method and Calinski-Harabasz index were used to validate the number of cluster solutions obtained with the clustering methods. The results of the elbow method and Calinski-Harabasz index are presented below.

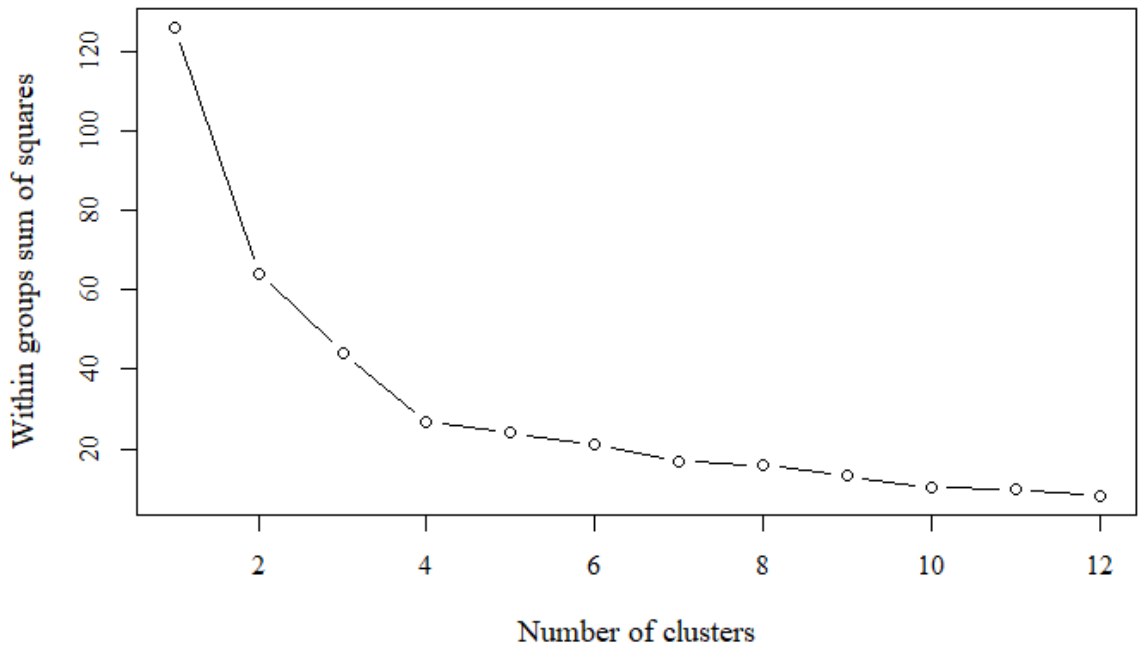

Figure 2. Elbow methods for financing dimension data

Calinski-Harabasz-index:

2 clusters: 9.34,
3 clusters: 31.73,
4 clusters: 47.31,
5 clusters: 40.97,
6 clusters: 39.90,
7 clusters: 36.33,
8 clusters: 36.10,
9 clusters: 37.62

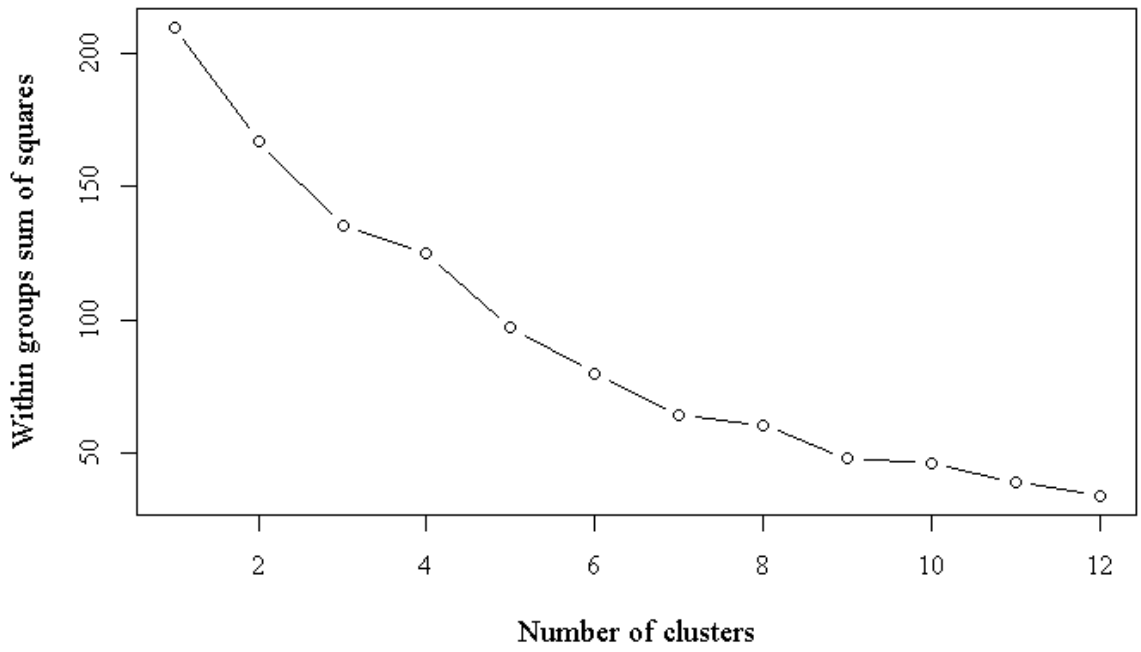

Figure 3. Elbow method for provision dimension data

Calinski-Harabasz-index:

2 clusters: 9.32,
3 clusters: 9.14,
4 clusters: 11.5,
5 clusters: 12.19,
6 clusters: 11.49,
7 clusters: 10.98,
8 clusters: 10.31,
9 clusters: 9.48

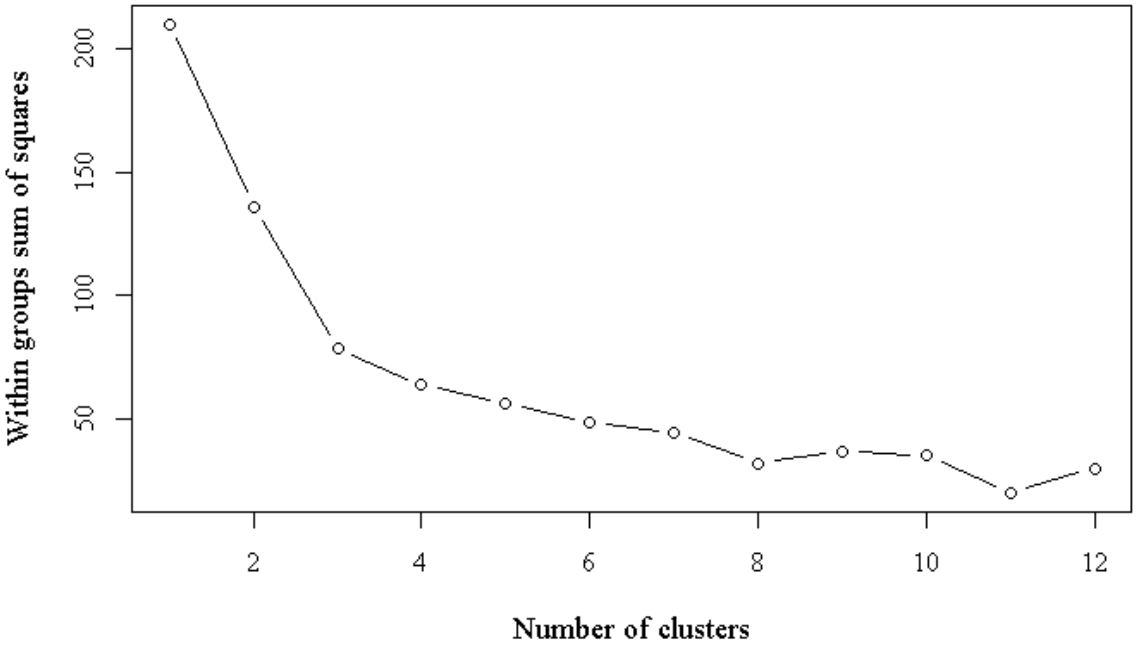

Figure 4. Elbow method for outcome dimension data

Calinski-Harabasz-index:

2 clusters: 21.32,
3 clusters: 13.29,
4 clusters: 28.34,
5 clusters: 29.47,
6 clusters: 25.69,
7 clusters: 23.39

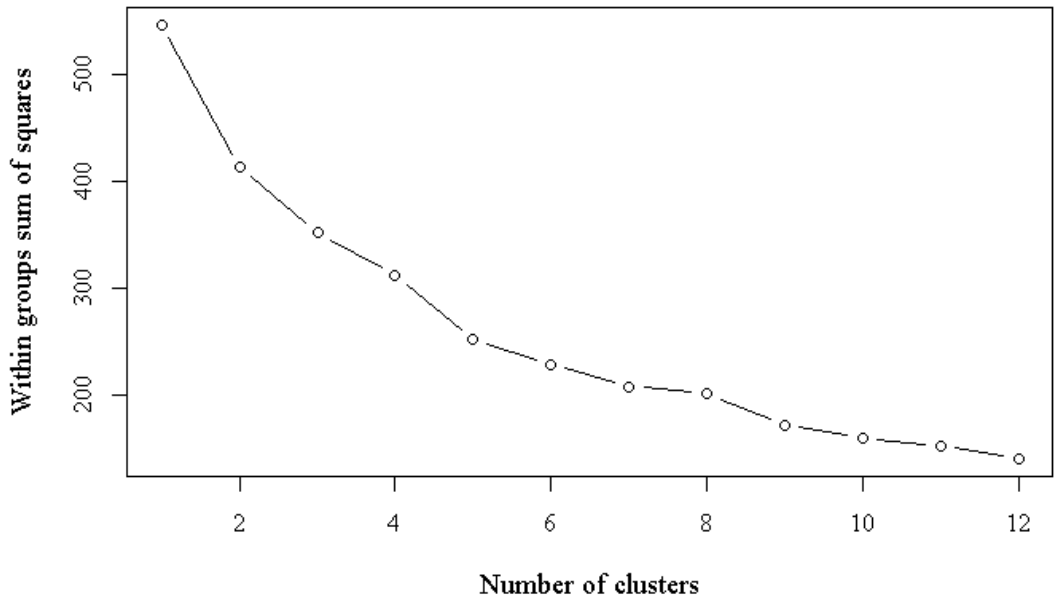

Figure 5. Elbow method for combined dimensions data

Calinski-Harabasz-index:

2 clusters: 11.14,
3 clusters: 12.00,
4 clusters: 11.72,
5 clusters: 10.62,
6 clusters: 9.83,
7 clusters: 9.24,
8 clusters: 8.84,
9 clusters: 8.34

Results of clustering with average linkage, k-means and k-medoids methods

To strengthen the robustness of our results, we compare the hierarchical clustering results, using the complete linkage method, with the results obtained from other types of cluster analysis which are presented below. The following clustering methods function as sensitivity analyses. Average linkage method is also a hierarchical clustering technique which measures the distance of two clusters as the average of the distance between all unit pairs from each group (Everitt et al. 2011, 76). However, complete linkage method defines the distance between two groups as the distance between the two furthest units of those groups (Everitt et al. 2011, 76). K-means clustering tries to find a cluster solution that minimises the within-group sum of squares over all variables, and as the algorithm uses variable means, it can only be used for data with continuous variables. For data that contains continuous and categorical variables, we used an alternative for k-means clustering: k-medoids clustering. Compared to k-means, k-medoids algorithm uses medoids as cluster centres instead of means. Medoid is the most central unit of a cluster as it is located the closest to all other units of the cluster (Kassambara, 2017, 48). The results obtained by complete linkage, average linkage, k-means and k-medoids methods are slightly different, mostly because of the ways in which the proximities of different cluster units are calculated. However, Everitt et al. (2011, 83) note that analyses with different clustering choices are generally recommended to check for robustness of the results. Complete linkage was chosen over average linkage as average linkage seems to isolate more outliers (see appendix 2, figures 9-11) and the dendrograms of the results with average linkage do not seem to describe the data with the four-cluster solution as well as complete linkage (four-cluster solutions was supported by the elbow method and Calinski-Harabasz index). Hierarchical clustering technique was chosen over the partitioning clustering methods (k-means and k-medoids) as the results of hierarchical clustering help with the decision of the optimal number of clusters, whereas partitioning clustering requires the number of clusters to be set in advance (Everitt et al., 2011, 95, 111).

References

Everitt, B. S., Landau, S., Leese, M., & Stahl, D. (2011). *Cluster analysis* (5th ed.). Chichester, West Sussex, U.K.: Wiley.

Kassambara, A. (2017). *Practical guide to cluster analysis in R: Unsupervised machine learning.* United States: STHDA.

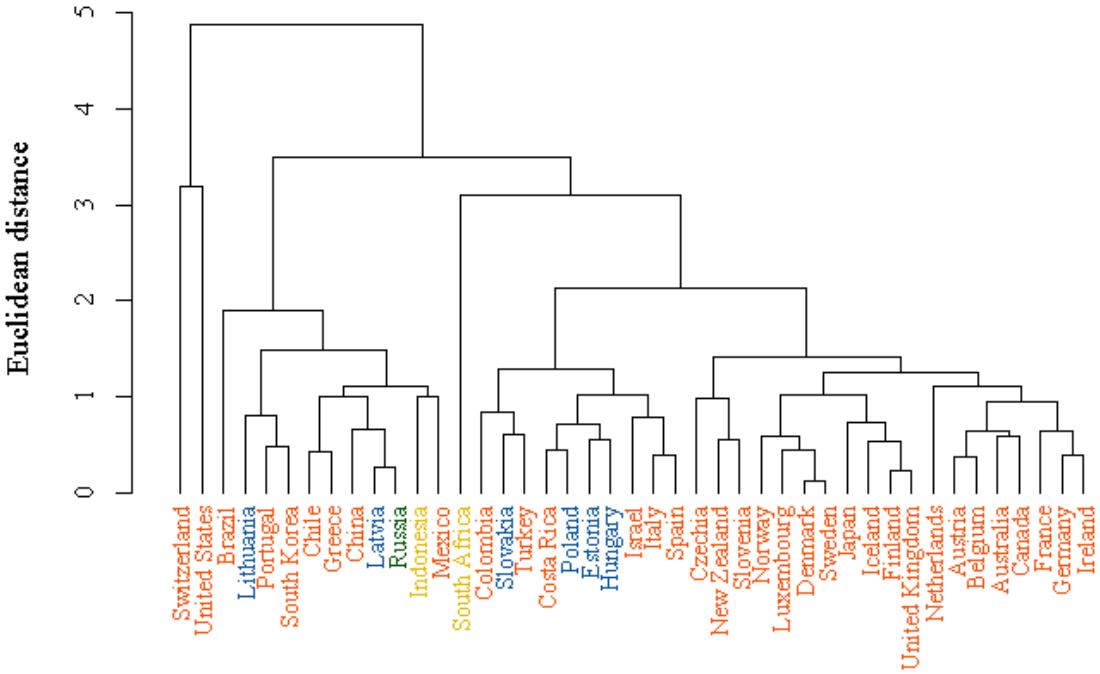

Figure 6. Dendrogram of financing clusters with average linkage method

Healthcare system financing types with K-means analysis:

1. Colombia, Costa Rica, Czechia, Estonia, Hungary, Israel, Italy, Poland, Slovakia, Slovenia, South Africa, Spain, Turkey

2. Switzerland, United States

3. Brazil, Chile, China, Greece, Indonesia, Latvia, Lithuania, Mexico, Portugal, South Korea, Russia

4. Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Iceland, Ireland, Japan, Luxemburg, Netherlands, New Zealand, Norway, Sweden, United Kingdom

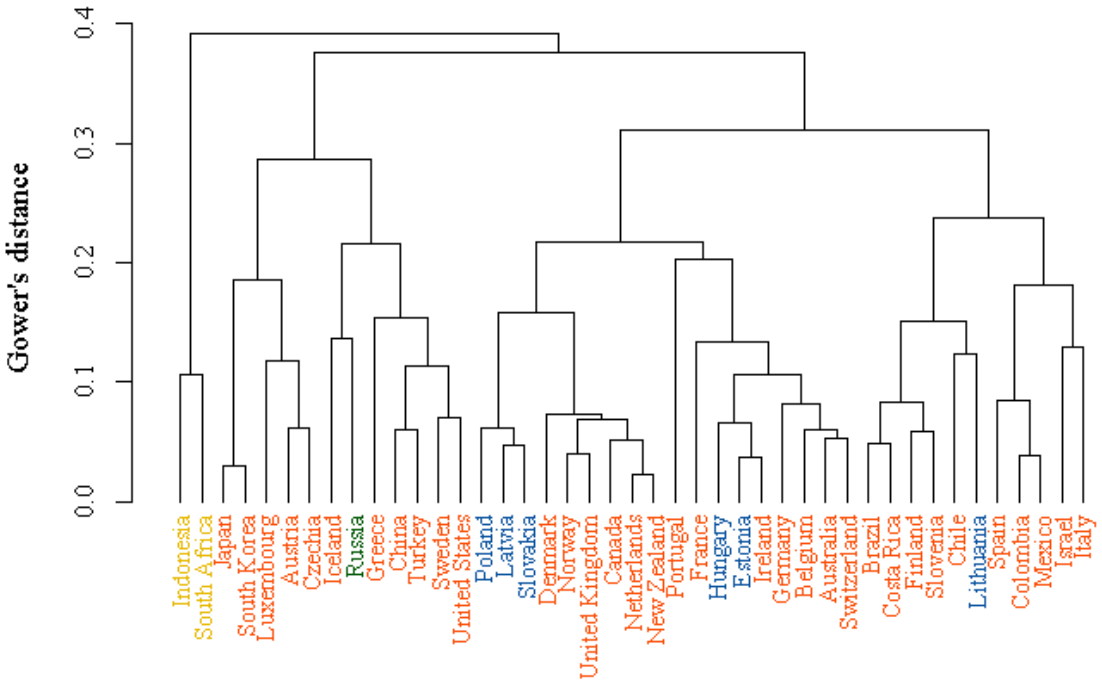

Figure 7. Dendrogram of provision clusters with average linkage method

Healthcare system provision types with K-Medoids analysis (for data including categorical variables):

1: Australia, Austria, Belgium, Czechia, Estonia, France, Germany, Hungary, Ireland, Japan, Luxemburg, South Korea, Switzerland (K-medoid: Belgium)

2: Brazil, Chile, Colombia, Costa Rica, Finland, Israel, Italy, Lithuania, Mexico, Portugal, Slovenia, Spain (K-medoid: Finland)

3: Canada, Denmark, Latvia, Netherlands, New Zealand, Norway, Poland, Slovakia, United Kingdom (K-medoid: Netherland)

4: China, Greece, Iceland, Indonesia, Russia, South Africa, Sweden, Turkey, United States (K-medoid: Turkey)

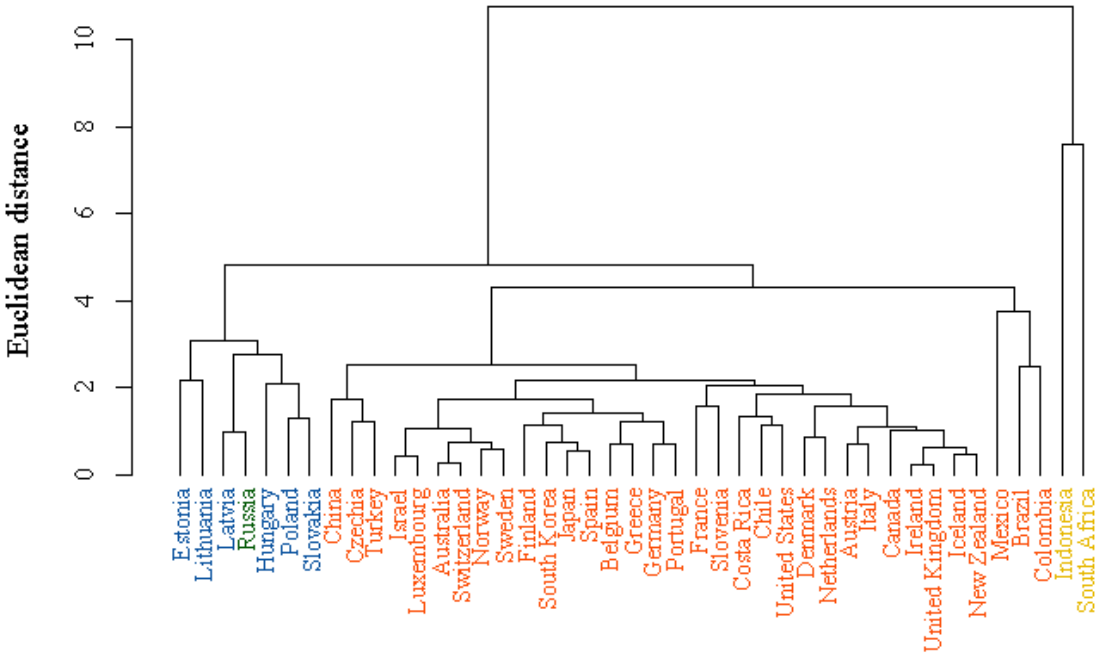

Figure 8. Dendrogram of outcome clusters with average linkage method

Healthcare system outcome types with K-Means analysis:

1: Australia, Austria, Belgium, Canada, Chile, Costa Rica, Czechia, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Israel, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Slovenia, South Korea, Sweden, Switzerland, Turkey, United Kingdom, United States

2: Indonesia, South Africa

3: Brazil, China, Colombia, Mexico

4: Estonia, Hungary, Latvia, Lithuania, Poland, Russia, Slovakia

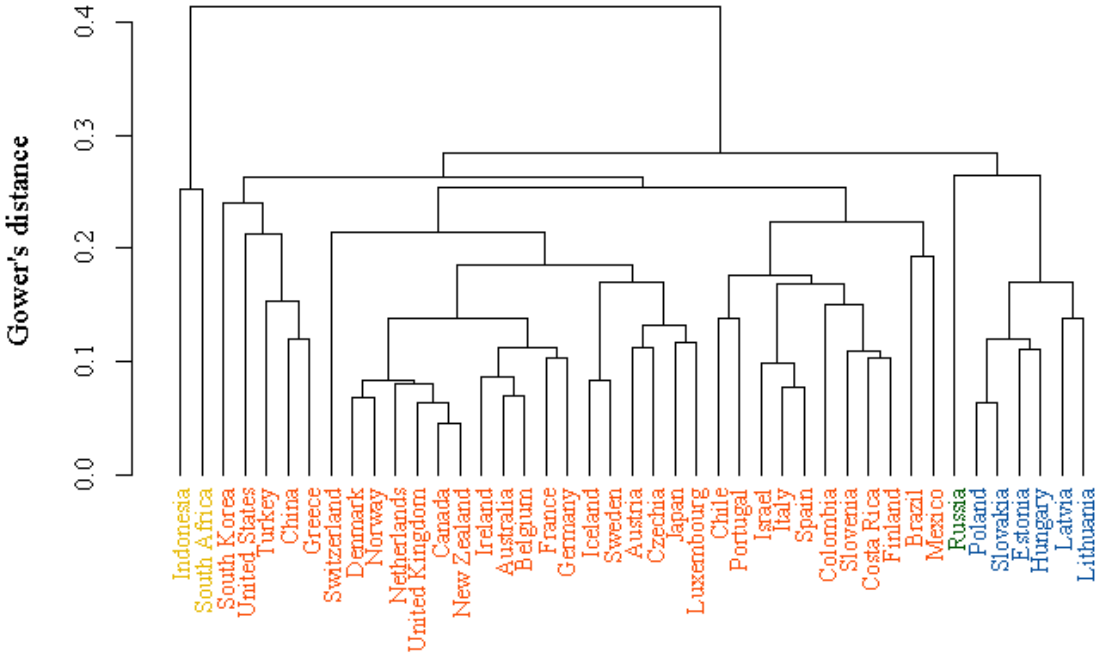

Figure 9. Dendrogram of combined clusters with average linkage method

Healthcare system combined types with K-Medoids analysis:

1: Australia, Austria, Belgium, Canada, Czechia, Denmark, France, Germany, Ireland, Japan, Luxembourg, Netherlands, New Zealand, Norway, Sweden, Switzerland, United Kingdom (K-medoid: Belgium)

2: Brazil, China, Greece, Indonesia, Portugal, Russia, South Africa, South Korea, Turkey (K-medoid: China)

3: Chile, Colombia, Costa Rica, Finland, Iceland, Israel, Italy, Mexico, Spain (K-medoid: Spain)

4: Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia (K-medoid: Poland)