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Studying social determinants of health using fuzzy-set Qualitative Comparative Analysis: A worked example

Lauri Kokkinen

Faculty of Social Sciences, Tampere University, Tampere, Finland

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ABSTRACT

Using fuzzy-set Qualitative Comparative Analysis (fsQCA), we present an alternative method for studying the social determinants of health (SDHs) that focuses on their configurational paths leading to population health outcomes. In our worked example, we examine the macrosocial determinants of infant mortality based on data covering 149 countries. First, we applied regression techniques to assess the net effects of key macrosocial determinants. Second, we used fsQCA to analyze the same data and identify the configurational paths. We calibrated the macrosocial determinants in terms of both advantages and disadvantages and revealed the configurations of (dis)advantages consistently linked to high infant mortality rates and low infant mortality rates. The regression analysis showed that the net effects of national economic performance, democracy level, inequality, and women's autonomy were all statistically significant. Together, they explained 83% of the variance in infant mortality rates between countries. Following the fuzzy-set analysis, the two main configurational paths to achieve low infant mortality rates were high women's autonomy together with high economic performance and high women's autonomy together with low inequality and full democracy. The main paths that left countries burdened with high infant mortality rates were low economic performance together with either low women's autonomy or high inequality. We conclude that different SDH configurations may lead to the same health outcomes. Therefore, it may not always be sufficient to say which variables matter the most universally, and by using fsQCA, it is possible to move from treating SDHs as competing independent variables to using them in configurations to explain health outcomes.

1. Introduction

Previous research has teased apart the effects of different social determinants of health (SDHs), covering the entire spectrum of conditions in which people are born, grow, work, live, and age (Marmot and Wilkinson, 2005). This interest dates to at least the 19th century with the work of Rudolf Virchow, who found that epidemics are largely social in origin (Virchow, 1848). A more recent milestone was reached, when Geoffrey Rose (1985) distinguished the causes of incidence in populations and the causes of disease among individuals. Then, a report from the WHO's Commission on Social Determinants of Health highlighted the social determinants of health inequities within and among societies (CSDH, 2008). Since then, the macrosocial determinants of health (e.g., politics, economics, and women's status in society) have been increasingly emphasized over individual-level interventions to improve population health and tackle health inequities (Keyes and Galea, 2016).

By isolating the average impact of SDHs across a range of countries, previous studies have uncovered crucial nonmedical mechanisms (that otherwise would have remained hidden or speculative) and enabled evidence-based policies (CSDH, 2008; Solar and Irwin, 2010). However, the very logic of conventional net effect analyses—which is to estimate the isolated impact of individual variables on health outcomes (while holding all else equal)—conflicts with understanding the core nature of SDHs as configurational.

Recently, there have been calls for a "systems approach" that seeks to understand how SDHs work in combination with each other and integrate action on different SDHs to reduce disease burden and inequalities (Eckersley, 2015; Marmot and Bell, 2019). The idea of explaining the outcomes of variables by examining how they work in combination, instead of looking at independent variables in isolation, has not yet gained footing in the empirical SDH literature, including the literature on the macrosocial determinants of health (Galea, 2007). Instead, this concept was famously utilized in Gösta Esping-Andersen's (1990) work on welfare states. Esping-Andersen presented welfare states as macro configurations of institutions created by historical coalitions of actors (e.

E-mail address: lauri.kokkinen@tuni.fi.

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g., the working class and the middle class) that institutionalized power structures over time, thus shaping subsequent politics and policies (e.g., unemployment benefits). Evidently, the political equality of democracy and the economic inequality of capitalism did not lead to similar outcomes across all emerging welfare states, and Esping-Andersen explained this variation by simultaneously examining the power of organized groups and the actual historical coalitions that they stroke. However, Esping-Andersen's work was not fully configurational in its methodology. Rather, it was based on, and hence limited by, symmetric correlational reasoning.

In this paper, we build on the work of Charles Ragin, who has developed the field of comparative methodology to bridge the gap between variable-based quantitative research and case-oriented qualitative research (Ragin, 1987, 2000, 2008, 2014; Ragin and Fiss, 2017). Fuzzy-set Qualitative Comparative Analysis (fsQCA) incorporates Ragin's theoretical insights to bridge quantitative and qualitative methodologies. Namely, fsQCA can replicate the logic of case-study analysis in a mathematical framework based on asymmetric and set-theoretic reasoning, which distinguishes it from methods derived from statistical theory. Unlike in variable oriented SDH analyses, the effect of a social determinant will not necessarily be the same across different contexts in fsQCA because of the mathematical framework that it builds upon. A social determinant may be relevant in one context but irrelevant in another. Yet, in another context, the absence of this causal condition may be relevant to the same outcome.

Unlike previous studies that depended on symmetric correlational reasoning, this study builds on Ragin's mathematical framework and asserts that SDHs and their configurations with positive population health outcomes may differ from those determinants associated with negative population health outcomes. More specifically, this paper presents a unique method for analyzing SDHs and a worked example of the macrosocial determinants of infant mortality based on data covering 149 countries.

1.1. *Background for a worked example of the macrosocial determinants of infant mortality*

Today, most newborns survive to fulfill their potential later in life, but there are still large differences in infant survival rates between countries. More than 80 countries worldwide have infant mortality rates that are at least 20 times higher than those of Scandinavian countries (Wang et al., 2016). The affected infants do not die from new incurable diseases. Rather, they die from the same causes that earlier killed newborns throughout the world, such as undernutrition, diarrhea, tuberculosis, pneumonia, and respiratory diseases (Deaton, 2015). In response, a large body of research has investigated why infants continue to die from preventable causes.

Poverty is the most studied candidate for persistent high infant mortality rates, and comparative studies have shown that national economic performance affects infant survival rates (Pritchett and Summers, 1996). Higher gross domestic product per capita creates higher levels of private income for households to improve their lives, and richer societies can more easily afford the basic services that help reduce infant mortality (e.g., health care, family planning, water supply, sanitation, and pest eradication) than poorer societies.

Notably, national indicators of economic success rarely clarify who receives certain funds. Economic inequality—which is often intertwined with ethnic, linguistic, and religious inequality—can become entrenched through the political power that money can buy (Gilens, 2012). In the context of extreme inequality, the wealthiest have no need for universal state-provided health services or education and are instead motivated to restrict these services and support tax cuts for businesses and the wealthy (Stiglitz, 2012). In the words of Filmer et al. (2000), "[T]he public budget for health is principally absorbed by public hospitals staffed by doctors expensively trained at public expense who use costly medical technology to treat conditions of the urban elite, while in those same countries children die from diseases that could have been treated for a few cents or avoided altogether with basic hygiene practices."

According to previous studies, democracy creates opportunities to take advantage of low-cost basic services and freely available scientific knowledge to save newborns on a large scale. Democratic governments are generally more accountable to their populations than non-democratic governments, as democratically contested elections compel rulers to act for the good of the voters (Sen, 1999). Democracies also tend to contain more stringent institutional checks and balances (e.g., independent statistical offices and accountability agencies such as courts), which constrain government powers in the interest of the public good (Lake and Baum, 2001). In addition, democracy affects basic service provision and infant mortality through mechanisms such as freedom of information, freedom to organize, changes in political culture, and changes in citizen expectations (McGuire, 2010).

Additionally, the critical role of women in reducing infant mortality rates should also be highlighted. Global improvements in education have enabled women to make better use of scientific knowledge and demand and utilize basic services in the interests of their newborns' well-being (Ware, 1984). Moreover, the infant mortality literature has increasingly focused on women's autonomy in terms of their self-determination, right to education, and wider participation in society. Thus, alongside the traditional candidates of economics and politics, women's autonomy has been elevated in the literature and used to explain global variations in infant mortality rates (Caldwell and Caldwell, 1993; Shandra et al., 2004; Shen and Williamson, 2001).

In summary, the four macrosocial determinants of infant mortality that we focused on in this study were national economic performance, democracy level, inequality, and women's autonomy, which were all suggested by previous high-quality studies (e.g., Babones, 2008; Powell-Jackson et al., 2011; Pritchett and Summers, 1996; Shandra et al., 2004; Shen and Williamson, 2001; Wigley and Akkoyunlu-Wigley, 2017).

1.2. *A set theory primer for studying configurations of the social determinants of health*

Probability theory and statistics have predominantly been used to model reality in SDH research. However, set theory can model complex realities better than traditional theories. Set theory, developed by Georg Cantor in the 1870s, specializes in the field of mathematics that studies collections of elements (Cantor, 1874). In classical set theory, elements of any kind can be collected into a set, but an element always either belongs to or does not belong to a set. The modern fuzzy set theory permits the gradual assessment of the membership of different elements in a set (Zadeh, 1965). Therefore, it is possible with fuzzy sets to use set-theoretic reasoning to allow for fine gradations in the degree of membership. This kind of theoretical approach offers two major advantages for studying SDH configurations.

First, fuzzy set theory includes a different approach to causality—the complexity approach—in comparison to probability theory (Ragin, 2008). As the default analytical starting point, causal complexity, defined here as a situation in which an outcome may follow from different combinations of SDHs, offers a novel theoretical–methodological approach to studying SDH configurations, and its thorough examination entails the consideration of all logically possible combinations. In this way, fuzzy set theory also enables the recognition of the growing interest in the systems approach that has led to the perception of SDH outcomes as an emergent property of a dynamic system (Fink et al., 2016). Emergent properties cannot be estimated with precision by using known interactions among components, so novel approaches, such as fsQCA, are needed to shed light on how different determinants interact with and lead to emergent patterns of population health.

Second, fuzzy set theory not only enables the integration of different theories of SDHs through causal complexity, but also allows their study in specific contexts. For example, it allows context to be viewed as a dynamic concept (i.e., having a historical past and present) that allows for mechanisms rooted in institutions, actors, and processes within the context. Moreover, it does not accept a reductionist approach with thought linearity (i.e., a single determinant that influences health outcomes in a linear fashion, despite the context with other determinants, present or absent). It also questions the ability to precisely generalize the determinants of health outcomes from one context to another. Furthermore, fuzzy set theory makes it possible to construct experimental design-like contrasts (where only one SDH is allowed to vary at a time) and thus offers a thorough analysis of the effects of different SDHs in specific contexts. This is important, as social scientists must engage counterfactual cases in some way because naturally occurring social science data are often limited in their diversity and present only some of the relevant empirical combinations (Ragin, 2008).

1.3. Aim of the paper

Our aim is to present a real alternative method to conventional SDH analysis, which places independent variables in competition with each other. Instead, our method identifies how SDHs configure in different ways to impact health outcomes. By establishing the benefits of fsQCA, we can shift the academic focus from isolated variables to contexts and configurations. Previous studies on the effects of SDHs have typically ignored such questions because they treat each social determinant as an isolated explanatory variable.

Furthermore, we aim to build a theoretical understanding of the relationship between SDHs and health outcomes in different contexts. This study separately analyzed the configured (dis)advantages to identify those conditions linked to either high or low infant mortality rates. These separate analyses are important and novel in the study of SDHs because the configured (dis)advantages associated with a health outcome may differ from the configured (dis)advantages associated with its absence. Previous studies have not identified this asymmetry, given that they have mainly relied on symmetric correlational reasoning.

2. Materials and methods

2.1. Data

To study infant mortality and its macrosocial determinants, we used the best available data from respected organizations and academic research groups, such as the World Bank, the United Nations University World Institute for Development Economics Research (UNU-WIDER), and the Center for Systemic Peace's Polity Project (see Table 1). We included all 149 countries with information on infant mortality rates and all four macrosocial determinants applied in this study (i.e., economic performance, democracy level, inequality, and women's autonomy). Our rationale for case selection regarded the availability of data (Hanckel et al., 2021). The outcome was the infant mortality rate for 2019, which was drawn from the World Bank's DataBank and developed by the United Nations Inter-agency Group for Child Mortality Estimation (UN IGME) (composed of UNICEF, WHO, World Bank, UN Population Division). This group makes infant mortality estimates as comparable as possible by using all available information and implementing statistical models to reach the best estimated trend by fitting country-specific regression models of mortality rates against their reference dates. To focus on long-term exposure and avoid yearly fluctuations, we used a 60-year mean for all macrosocial determinants except women's autonomy, which had a 50-year data range available when women's education was used as the indicator of autonomy. For each measure, the same organization or research group collected the data at several points. The consistency and quality of the data are controlled by well-respected data providers, and the datasets used do not include any information on individual subjects. All data are freely available and can be downloaded electronically, allowing other researchers to replicate our analysis.

Table 1
Overview of the datasets.

Macrosocial determinant	Measure	Dataset	Data provider	Year(s)
	Infant mortality rate	World Bank DataBank	World Bank	2019
Economy	Gross domestic product	World Bank DataBank	World Bank	1960–2019
Democracy	Level of democracy	Polity IV Database	The Polity Project	1960–2019
Inequality	Income inequality (GINI coefficient)	World Income Inequality Database	UNU World Institute for Development Economics Research (UNI-WIDER)	1960–2019
Women's autonomy	Secondary school enrollment rate, female	World Bank DataBank	World Bank	1970–2019

2.2. Research methods

We employed descriptive statistics and regression analysis to provide a benchmark for the configurational analysis. Using linear regression models, we replicated the net effects of all four key macrosocial determinants identified in previous studies with the SPSS software package version 27.

To identify the configurational paths, we treated each country as a separate case and used set-analytic methods and truth table techniques to analyze the same data with the fsQCA software package.

2.3. fsQCA calibration

We first translated our variables into sets by distinguishing a range of cases. For instance, "infant mortality" and "women's autonomy" are source variables, but they do not make much sense as sets. By adding adjectives, we created, for example, "low infant mortality" and "high women's autonomy" to distinguish specific sets of cases. We then determined the membership scores for each case in each set. Our source variables were ordinal- and interval-scale variables by nature, thus demonstrating a variation that could potentially be meaningful to a set. We accounted for this variation when assigning set memberships by basing all the conversions on theoretical knowledge and empirical evidence. As suggested by Ragin (2008), we defined values indicating a) the threshold for full set membership, b) the threshold for full set non-membership, and c) the distinction between the more-in and more-out of a set.

Table 2 shows our calibrations. Regarding the outcome, we based the thresholds on the United Nations Sustainable Development Goals (SDGs) and considered 12 deaths per 1000 infants to be the threshold for full membership in the set "low infant mortality" and two times this value to be the threshold for full non-membership (United Nations, 2015). We used the exact opposite approach to define the thresholds for the set "high infant mortality" (Paykani et al., 2018). We drew the thresholds for economic performance from the World Bank: high-income economies had a gross national income (GNI) per capita of $12,696 or higher, upper-middle-income economies had GNIs that ranged from $12,695 to $4,096, lower-middle-income economies had GNIs that ranged from $4095 to $1,046, and low-income economies had a GNI of $1045 or less (World Bank, 2021). Moreover, we crafted thresholds for democracy by following the Polity IV Project: full democracies had a Polity score of 10 (e.g., Australia and Canada), democracies had scores from 6 to 9 (e.g., Argentina and India), anocracies had scores from 5 to −5 (e.g., Egypt

Table 2
fsQCA calibration.

	Full membership	Crossover point	Full non-membership
Low infant mortality rate	12	18	24
High infant mortality rate	24	18	12
High economic performance	12,696	8396	4095
Low economic performance	1045	2570	4096
Full democracy	10	7.5	5
Full autocracy	−10	−3	6
Low inequality	35	40	45.0
High inequality	55	50	45.1
High women's autonomy	100	75	50
Low women's autonomy	40	45	51

and Russia), and full autocracies had scores from −6 to −10 (e.g., China and Cuba) (Marshall and Elzinga-Marshall, 2017).

To the best of our knowledge, no commonly shared theory defines low or high inequality membership, and the same applies to women's autonomy. Hence, we used a Gini index score of 35 as the threshold for full membership in the set "low inequality." Countries with scores less than 35 are often represented as green zones in traffic light illustrations. In contrast, we applied a score of 55 as the threshold for full membership in the set "high inequality," given that countries with scores above 55 are often represented as red zones in the illustrations (Ward and Viner, 2017). We selected 100% female school enrollment as the threshold for full membership in the set "high women's autonomy." After consulting Perkiö (2021), we then used 40% female school enrollment as the threshold for full membership in the set "low women's autonomy."

2.4. fsQCA analysis

A key tool for systematically analyzing causal complexity with fsQCA is the truth table (Ragin, 2008). We analyzed the overlapping effects of different SDHs on infant mortality rates by using the truth table technique to address the different configurations of the case characteristics. We formed the rows of each truth table from all the logically possible configurations of the selected SDHs, and we calculated the degree to which each country case was a member of each row with fuzzy algebra. Thus, the results of our truth table analysis revealed all the specific contexts that allowed for specific configurations. Using the truth tables, we compared the set-theoretic connection between low (or high) infant mortality rates and all possible combinations of the SDHs. In doing so, we discovered the strength of the links between coinciding advantages and low infant mortality rates as well as those between coinciding disadvantages and high infant mortality rates. Based on our truth table analysis, we drew and assessed the causal recipes that showed the configurations of (dis)advantages linked to low (or high) infant mortality rates for each case set.

When assessing fsQCA solutions, it is important to evaluate both coverage and consistency (Ragin, 2008). Set-theoretic coverage is scored from 0 to 1. In this context, set-theoretic coverage refers to the share of the outcome that is explained by each solution term and by the entire solution. Like significance, it indicates if the empirical connection in question merits a closer attention. The total solution coverage refers to the proportion of the membership in the outcome that can be explained by all individual causal recipes (i.e., the complete solution). Raw coverage refers to the proportion of the membership in the outcome that can be explained by a specific causal recipe in the solution and may include cases also covered by other solutions. In contrast, unique coverage refers to the proportion of cases that are covered by only one solution.

Set-theoretic consistency is also scored from 0 to 1. Set-theoretic consistency refers to the degree to which membership in the solution is a subset of membership in the outcome. Like strength, it signals the empirical importance of the connection in question. For a case to be considered consistent, its membership in the solution term(s) must be less than or equal to its membership in the outcome. We measured the total solution consistency by the degree to which membership in the set of solution terms is a subset of membership in the outcome.

The key to set-theoretic analysis is to find a balance between consistency and coverage. The fsQCA algorithm requires the researcher to specify the criteria to both exclude and code configurations so that the logically irrelevant conjunctions can be eliminated. Following Ragin and Fiss (2017), we used 0.8 as the threshold for consistent subsets of the outcome and 2% of all cases (3 of 149 cases) as the frequency threshold.

The fsQCA algorithm applies minimization rules to simplify the configurations and produces three solutions: (1) a complex solution that avoids using the logically possible configurations that lack empirical instances; (2) a parsimonious solution that allows the use of all logically possible configurations regardless of their empirical plausibility and existing substantive knowledge; and (3) an intermediate solution that permits the use of logically possible configurations with empirical instances and the incorporation of remainders that are expected to affect the outcome based on previous empirical research. In this analysis, we incorporated existing knowledge on the (dis)advantages of SDHs into the production of intermediate solutions.

3. Results

Table 3 shows the correlations from the univariate and multivariate regression models used to predict infant mortality rates. In summary, we found that the set of the four SDHs—economic performance, levels of democracy, inequality, and women's autonomy— explained 83% of the variance in infant mortality rates between countries. These SDHs all remained statistically significant in the multivariate model. Our multivariate model gave a slightly different result when we tested under-five mortality as a measure of health instead of infant mortality, but the big picture remained comparable.

Table 4 examines cases sharing specific configurations of advantages and presents all 16 combinations of the four macrosocial determinants of health linked to low infant mortality rates. Six combinations satisfied the consistency threshold of 80%, but one such combination only had

Table 3
Median (range) of each variable and correlations from the univariate and multivariate regression models predicting infant mortality rates.

	Median (range)	Correlations from univariate regression models predicting infant mortality rates	Correlations from multivariate regression models predicting infant mortality rates
Infant mortality rate	14.3 (1.7–81)		
Economy	4470.9 (219–92234)	−0.64	−0.42
Significance		$p < 0.001$	$p < 0.001$
Democracy	5.8(-10–10)	−0.46	−0.15
Significance		$p = 0.001$	$p = 0.021$
Inequality	38.2 (26.5–66.9)	2.53	1.21
Significance		$p < 0.001$	$p < 0.001$
Women's autonomy	87.2 (7.1–167.3)	−1.42	−0.56
Significance		$p < 0.001$	$p < 0.001$
Explained variation			91%
Adjusted R^2			0.83

Table 4
Truth table showing the combinations of the macrosocial determinants of health linked to low infant mortality rates.

High economic performance	Low inequality	Full democracy	High women's autonomy	Number of conforming cases	Subset consistency
Yes	Yes	Yes	Yes	31	0.998333
Yes	No	No	Yes	7	0.898305
Yes	No	Yes	Yes	5	0.942541
Yes	Yes	No	Yes	4	0.980657
Yes	No	Yes	No	1*	0.843537
Yes	No	No	No	1*	0.688804
Yes	Yes	No	No	0*	
Yes	Yes	Yes	No	0*	
No	No	No	No	27	0.24409
No	Yes	No	No	24	0.233612
No	Yes	No	Yes	18	0.757195
No	Yes	Yes	Yes	9	0.897494
No	No	Yes	Yes	8	0.678471
No	No	Yes	No	6	0.522704
No	No	No	Yes	5	0.796875
No	Yes	Yes	No	2*	0.478873

*Rows that failed to meet the frequency threshold of 2% of cases.

one conforming case and did not meet the frequency threshold of three cases. The remaining five combinations covered 56 countries. The combinations all included high women's autonomy and a favorable economic situation, either high economic performance or low inequality. Interestingly, there were also five cases in which women's autonomy was the only advantage present and yet the subset's consistency still came very close to meeting the threshold (0.796875).

Table 5 displays the fsQCA intermediate solution for low infant mortality rates. By applying minimization rules the algorithm identified simpler version with comparable consistency but greater coverage compared to more complex versions shown in Table 4. Two main configurational paths were: (1) high women's autonomy together with high economic performance and (2) high women's autonomy together with low inequality and full democracy. The solution is very consistent and accounts for 65 percent of the sum of the membership scores in the outcome.

Table 6 presents all 16 combinations of the four macrosocial determinants of health linked to high infant mortality rates. Two combinations satisfied the consistency threshold and the frequency threshold. These two combinations covered 34 countries. They both included low economic performance and the other ingredient needed was either low women's autonomy or high inequality. Interestingly, low women's autonomy alone satisfied the consistency threshold but there were only two conforming cases. This did not satisfy the frequency threshold.

Finally, Table 7 shows the fsQCA intermediate solution for high infant mortality rates. There were two main configurational paths: (1) low economic performance together with low women's autonomy and (2) low economic performance together with high inequality.

Table 5
fsQCA coverage and consistency for low infant mortality rates, which represent the combination of the associated determinants.

	Raw coverage	Unique coverage	Consistency
High women's autonomy*High economic performance	0.575938	0.217771	0.976481
High women's autonomy*Low inequality*Full democracy	0.430758	0.0725904	0.975623
Solution coverage: 0.648529			
Solution consistency: 0.964261			

4. Discussion

4.1. Main findings from the worked example on the macrosocial determinants of infant mortality

In this study, we assessed the conditions under which infants continued to die in 2019 despite the freely available scientific knowledge and low-cost basic services that could save them. We first replicated the effects of the key macrosocial determinants of infant mortality from previous studies using regression techniques. We found that the net effects of national economic performance, democracy level, inequality, and women's autonomy were all statistically significant. Together, they explained 83% of the variance in infant mortality between countries. We then identified the relevant configurational paths using fsQCA. Following the fuzzy-set analysis the countries need not wait to be wealthy, equal, and democratic to achieve low infant mortality rate. The results clarified that the two main configurational paths to achieve high infant survival rates are high women's autonomy together with high economic performance and high women's autonomy together with low inequality and full democracy. Moreover, we found that the main paths that allowed high infant mortality rates to persist were low economic performance together with either low women's autonomy or high inequality.

The four macrosocial determinants of infant mortality used in this study were suggested by previous high-quality studies (e.g., Babones, 2008; Powell-Jackson et al., 2011; Pritchett and Summers, 1996; Shandra et al., 2004; Shen and Williamson, 2001; Wigley and Akkoyunlu-Wigley, 2017). On the one hand, the results of our replication analysis are in line with their findings. On the other hand, the fuzzy set analysis in this study showed that some of the studied (dis)advantageous SDHs were absent when a low (or high) infant mortality rate occurred, and a given (dis)advantageous SDH did not always lead to a specific outcome. Hence, some SDHs were not always necessary or sufficient, respectively.

Both main configurational paths to high infant mortality rates included low economic performance. However, together with high women's autonomy, either (1) high economic performance or (2) low inequality and full democracy could achieve low infant mortality rates. We found partial support for this finding in the literature. Some historical studies have shown that countries may not need to be wealthy to achieve low infant mortality rates (Caldwell, 1986; Dreze and Sen, 1989). For instance, Preston (1975) proposed that the low infant mortality rate in Europe and North America may largely be credited to advancements in scientific knowledge and the efficient implementation of said knowledge (e.g., public health interventions) rather than wealth.

Both main configurational paths to low infant mortality rates

Table 6
Truth table showing the combinations of the macrosocial determinants of health linked to high infant mortality rates.

Low economic performance	High inequality	Full autocracy	Low women's autonomy	Number of conforming cases	Subset consistency
Yes	No	No	Yes	30	0.980435
Yes	No	No	No	12	0.75
Yes	No	Yes	No	5	0.782913
Yes	No	Yes	Yes	4	1
Yes	Yes	No	No	4	0.808399
Yes	Yes	Yes	No	0	
Yes	Yes	No	Yes	0	
Yes	Yes	Yes	Yes	0	
No	No	No	No	67	0.133586
No	No	Yes	No	13	0.319787
No	Yes	No	No	8	0.54509
No	No	No	Yes	2	0.985882
No	Yes	Yes	Yes	1	1
No	Yes	Yes	No	1	0.348416
No	Yes	No	Yes	0	
No	No	Yes	Yes	0	

*Rows that failed to meet the frequency threshold of 2% of cases.

Table 7
fsQCA coverage and consistency for high infant mortality rates, which represent the combination of the associated determinants.

	Raw coverage	Unique coverage	Consistency
Low economic performance*High inequality	0.0686754	0.0408382	0.860153
Low economic performance*Low women's autonomy	0.518813	0.490976	0.983188
Solution coverage: 0.559651			
Solution consistency: 0.965435			

included high women's autonomy. Moreover, low women's autonomy was an ingredient in one of the two main paths to high infant mortality rates. Our findings are in line with those of previous studies that have raised women's autonomy alongside the traditional candidates of economics and politics to explain global variations in infant mortality rates (Caldwell and Caldwell, 1993; Shandra et al., 2004; Shen and Williamson, 2001). According to previous empirical research, women's education influences infant survival by enabling women to make better use of scientific knowledge and demand and utilize basic services in the interests of their newborns' well-being (Ware, 1984). Regarding the mechanisms underlying the importance of women's education, Amartya Sen (1999) found that literacy contributes to a woman's agency and promotes opportunities for her in different contexts, such as making decisions regarding her newborn's well-being. At the same time, Göran Therborn (2011) found that women's education is an important tool in breaking down the patriarchy (e.g., a husband's power over his wife or a father's power over his daughter), which is the key to more autonomy for women. Together, these two scholars point out the most important direct and indirect mechanisms (literacy and gender equity, respectively) that make women's education critical for the survival of their newborns. However, future studies should not use only educational credentials to measure women's autonomy—as was done in this study and in most prior studies—but directly incorporate self-determination and wider participation in society (e.g., labor market participation and the number of women in parliament). This would likely provide a clearer picture of degrees of autonomy, and its effects on infant mortality in different contexts.

Democracy was only present in one of the main configurational paths. According to previous studies, democracy creates opportunities to take advantage of low-cost basic services and implement scientific knowledge to save newborns. Nevertheless, this does not necessarily increase rates of infant survival, as witnessed by an inability to reduce day-to-day hunger and chronic malnutrition despite political democracy (Dreze and Sen, 1989) and interest group successes facilitated by democratic political institutions that oppose pro-poor basic health service reforms (McGuire, 2010). Schattschneider (1960) noted that "[t]he flaw in the pluralist heaven is that the heavenly chorus sings with a strong upper-class accent." Likewise, we found that full democracy could only sufficiently achieve low infant mortality rates together with low inequality and high women's autonomy.

Of course, there are other macrosocial determinants of infant mortality that we did not study in our worked example, such as foreign dependency. Significant funding from foreign sources (e.g., from the sale of natural resources) can make governments less responsive to the needs of their populations because this funding may reduce their need to collect taxes (Persson et al., 1997). Significant foreign financial aid may also make governments less accountable by providing resources without incentives for responsible spending (Bauer, 1976). Moreover, the freedom of many governments is constrained by the power of international lenders and multinational corporations (Shandra et al., 2004). Hence, the drawbacks of foreign dependency should be compared with the effect of external aid on infant survival rates. External health aid from foreign governments, international institutions, and foundations has saved millions of newborns in poor countries by, for example, providing antibiotics and vaccinations; helping to control disease-bearing pests; almost eliminating smallpox, polio, and river blindness; making oral rehydration therapy available; and offering bed nets to protect against malaria (Levine et al., 2004). As we did not find a clear measure of the advantages and disadvantages of foreign dependency, we decided not to include it in our worked example.

In addition, we did not include scientific innovations or the provision of basic services (e.g., vaccinations, antibiotics, trained attendance at birth, clean water supplies, improved nutrition, sanitation, and pest control) in our framework because our focus was on macrosocial determinants that determine the use these global innovations and services at the national level. Regardless, the evidence has long indicated that these proximate/microsocial determinants are important in saving the lives of newborns (Mosley and Chen, 1984).

4.2. *Broader methodological impacts*

In this paper, we introduced a new methodological-theoretical approach to understanding the global inequality in infant mortality. However, our configurational approach also creates novel opportunities to analyze other policy-relevant data because different paths to reach similar health outcomes do exist.

As shown in our worked example, there are major differences between the configurational analysis and the correlational regression analysis. Set coincidence and correlation are different phenomena, and correlational symmetric analysis combines the divergent patterns of (dis)advantages into a single coefficient. In doing so, it washes out essential differences and the underlying heterogeneity between these (dis)advantages. Because of this symmetry, the differences between the social determinants linked to low infant mortality rates and the social determinants linked to high infant mortality rates were invisible to the regression analysis in our worked example. Instead, by analyzing low and high infant mortality rates separately and calibrating the causal conditions in terms of their respective (dis)advantages, we demonstrated the differences in the configuration of the (dis)advantages for both outcomes.

Recent calls for a "systems approach" have emphasized that SDHs should be studied according to their causal complexity and emergence (Eckersley, 2015; Marmot and Bell, 2019). Following systems theory, the world consists of wholes (i.e., systems) containing properties, including emergent outcomes, that cannot be explained simply by accounting for their components (Mingers, 2014). Systems tend to show emergence in that their characteristics emerge from the collective behavior of their components. On this basis, Eckersley (2015) claimed that to understand how SDHs work, we must understand the patterns of interactions between them. In this paper, we presented fsQCA as an appropriate methodological tool for analyzing this kind of causal complexity and emergence.

Fundamentally, our methods also shape our understanding of the studied phenomena and the way in which debates about these phenomena spread beyond academia. Previous SDH studies have primarily used regression techniques based on competing explanatory variables to explain outcomes. This reflects the search for some "common feature for a group of countries, which is then held up as the key to success or failure until it fails to open the door in another context" (Deaton, 2015). The reality has shown that it is not always sufficient to say which variable matters the most universally, and the search for magic bullets has had detrimental consequences as well (Moss et al., 2006). According to our configurational approach, several different paths may lead to the same health outcome. In contrast to more traditional methods that assess the independent variables to explain the dependent variables, fsQCA does not presume that the effect of a certain social determinant will be the same across all country cases.

For example, a pressing question outside academia is whether infant mortality rates can be more efficiently decreased with or without foreign financial aid. In this case, net effect analyses are the best tool for assessing the average impact of any kind of foreign financial aid over a range of different contexts. For example, if official development assistance is increased across poor countries, what will the general impact be on infant mortality when considering all cases? The answer is important, but it does not answer under what configuration of other conditions will an increase in official development assistance achieve the desired impact on infant mortality rates. The context is important because the provision of foreign financial aid and the development of local institutions and capacities sometimes conflict with each other (Moss et al., 2006). If high rates of infant mortality in some contexts are not only a result of lack of money, but also of, for example, poor political institutions, giving large amounts of money to the recipient government will not necessarily lower infant mortality. Instead, at least in this example, it might be more effective to find ways to route a larger share of the money straight to mothers and poor families. Again, while our paper focuses on a methodological shift, such methods have the potential to shape real-life debates in the long run.

4.3. The main limitations of studying SDHs using fsQCA

fsQCA is not without its limitations, and researchers should consider them before choosing it as their methodological approach for studying SDHs. Ragin (2009) stated that while fsQCA is useful for exploring and testing social scientific theories with causal complexity, it does not hold the same degree of inferential capabilities as some conventional methods. Therefore, we suggest that fsQCA should not be used to replace conventional correlational methods. Rather, it should complement them with configurational analyses.

Especially with small-N studies, fsQCA must be theory driven. Hence, a researcher should not use a 'kitchen sink' approach and test every imaginable SDH. The addition of a new SDH exponentially increases the number of different combinations to be tested. If a researcher uses too many SDHs with a small number of cases, this can result in a sample that cannot provide examples of all the configurations of these SDHs. If too many SDHs are present, the analysis effectively becomes a mere description of the case characteristics instead of a determination of the configurations of SDHs that lead to successes and failures.

5. Declarations of interest

None.

Credit author statement

Lauri Kokkinen: Conceptualization, Methodology, Software, Formal analysis, Data curation, Writing Original Draft, Reviewing and Editing.

Data availability

Data will be made available on request.

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