Complexity in Nursing Homes

Neo-configurational approaches and Qualitative Comparative Analysis as method in nursing science to determine the influence of organizational factors in the complex adaptive system “nursing home”

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As well as to **Adrian Duşa**, who brought the world of QCA a little closer to me. A world where so much is still in motion.

Ich danke meiner Familie und meinen Freunden, die mich getragen und ertragen haben in dieser Zeit. Allen voran meine Frau Tanja.

"Sometimes science is so hard, it makes me sad."
- Nathan W. Pyle

*Nursing homes differ significantly
from soliloquizing thermostats!*

Für Jonas
und für alle, die nicht an mich geglaubt haben...

Abstract

Nursing homes are places of high complexity where staff, residents and the institution itself are in an interdependent, non-linear relationship. Therefore phenomena cannot be explained mono-causally and additively. The thesis focuses on the influence of organizational characteristics on resident outcomes. These characteristics are limited by a number of internal and external influences, such as legislation, economics, etc. This form of complex causality with its factors of equifinality, assymetry and conjunctural causation is the main reason why nursing homes are considered complex adaptive systems.

Organizational research has been aware of these methodological difficulties for many decades. However, the lack of a method capable of taking them into account has long led to a gap between theory and methods.

With the emergence and development of Qualitative Comparative Analysis by Charles Ragin in 1987, a way of closing this gap was found. The method is based on the principles of set theory and Mill's methods. With a synthesis of qualitative and quantitative elements, necessary and sufficient conditions for the emergence of an outcome are revealed through the analysis of a truth table. It is shown that although the method is already used in nursing science in several instances, it is still incomplete, erroneous, or not yet used in accordance with newest methodological developments in many places.

The own practical application shows that fundamental influences of organizational characteristics on the residents outcome "fall" can be demonstrated. The comprehensive organizational data from the research project "PiBaWü" were used for this purpose. However, the results also show that without the inclusion of person-intrinsic conditions no exhaustive solution can be found. In view of the high complexity of the phenomenon, this was to be expected.

Nevertheless, the method offers decisive advantages for nursing science due to its possibilities to act with low data levels and smaller case numbers. At the same time, the need for theoretically sound assumptions also presents the discipline with obstacles.

As a catalyst for the lack of theory-building in recent decades, it can still have a stimulating effect and be seen as a real progress.

Contents

List of abbreviations[1]

AltPflAPrV = Ausbildungs- und Prüfungsverordnung für die Pflegeberufe
csQCA = crisp-set QCA
CAS = complex adaptive systems
DCU = dementia care unit
DNQP = Deutsches Netzwerk für Qualitätsentwicklung in der Pflege
eci = exclusion, crossover point and inclusion
EEE = Einrichtungseinheitlicher Eigenanteil
ESA = Enhanced Standard Analysis
fsQCA = fuzzy-set QCA
HLU = home-like care unit
LHeimBauVO = Verordnung des Sozialministeriums zur baulichen Gestaltung von Heimen und zur Verbesserung der Wohnqualität in den Heimen Baden-Württembergs
LHeimMitVO = Landesheimmitwirkungsverordnung
LPersVO = Landespersonalverordnung
MDK = Medizinischer Dienst der Krankenversicherung
mvQCA = multi-value QCA
NBA = Neues Begutachtungsassessment
NCT = neo-configurational thinking
PG = Pflegegrad
PRE = Proportional Reduction in Error
PRI = Proportional Reduction in Inconsistency
QCA = Qualitative Comparative Analysis
RoN = Relevance of Necessity
SA = Standard Analysis
SGB = Sozialgesetzbuch
SMV = set-membership values
TESA = Theory-Guided Enhanced Standard Analysis
tQCA = temporal QCA
WTPG = Wohn-, Teilhabe- und Pflegegesetz

[1] Where needed, translations are provided in the text where the respective abbreviation is first used

Chapter 1

Complexity in nursing and its organizations

Shaving in the morning takes about 5-10 minutes, combing and hairdressing 1-3 minutes, dressing 8-10 minutes. At least that is what the time frame of the Medizinischer Dienst der Krankenversicherung[1] (MDK) showed until the beginning of 2017. According to SGB[2] XI §15, the claim to a "Pflegestufe"[3] was determined by summing up these time values. According to the implicit basic assumption of this care need measurement, care and care requirements can be broken down to individual operations. Partial aspects that in their entirety make up the activity of nursing.

This model was rightly criticised for many years, as it propagates a mechanistic understanding of nursing that does not occur in this way in the everyday work of a nurse. Successful, care-giving activities cannot be broken down into individual "atoms" that can be considered separately, but rather the focus is on the whole of actions, which in their interaction generates an added value [4].

Similarly, nursing homes cannot be reduced to the sum of individual services in order to differentiate "good" from "bad" facilities. Care services, structural conditions and personnel qualifications can, of course, create good preconditions when viewed in isolation. Seen as a whole, however, even such a home can be economically unprofitable or inadequate in terms of care. Therefore, the greatest possible number of "positive" factors is not necessarily decisive for success. In addition, there must be a further "modus operandi" that determines the success of a business, whether economically or in terms of care.

This paper aims to explore the role of complexity in understanding how a nursing facility works and to test a newer approach to complexity science to reveal complex organizational influences on home residents.

To this end, the problems of organizational research and the methodological challenges in the investigation of complex adaptive systems will be addressed first. This is followed by an examination of the characteristics of organizational features in nursing homes and the restrictions and influences they are subject to. Causal complexity, as a basis, then allows the choice of Qualitative Comparative Analysis as a scientific method for organizational research, which takes into account the principles of neo-configurational thinking (cf. Schneider and Wagemann, 2012, pp. 5f.).

The method is then presented in detail in the following and the current standard works are supplemented by the latest methodological findings of recent years. In addition, an extensive review and evaluation of its use within nursing science will be carried out before an exemplary application based on the data sets from the research project "PiBaWü" is carried out.

The advantages and disadvantages of QCA and its potential will be discussed finally.

[1]Medical Service of the Health Insurance Funds

[2]Social Security Code

[3]Care level

[4]The now established system of Pflegegrade/degrees of care no longer use time values as an orientation. However, the classification process is still deeply flawed (cf. Brühl and Planer, 2019)

1.1 The system "nursing home"

Nursing care and the context of a nursing home in which it is embedded is almost unquestionably complex. Nursing staff provide for residents with the most varied demands and needs for assistance. From assistance with the morning toilet to full responsibility for all areas of care for people with apallic syndrome, for example. Wishes and biographical characteristics, as well as the much-vaunted resident centricity, play an increasingly important role here, which prevents professional nursing staff from working in a highly standardised way. In addition to the direct work on the resident, there are also organizational requirements to be met. Communication with relatives and other players in the health care system such as doctors, hospitals, pharmacies and medical supply stores are just as much a part of the job description as documentation, care planning and evaluation. In addition, coordination must take place within the team, in the form of meetings and handovers, and within the institution, with house management and nursing service management. Personal requirements such as further training or additional qualifications, studies or similar also play a role.

All these requirements are not isolated from each other, but interlock, are interdependent, reinforce or hinder each other. The fall of an inhabitant is relatively simple in its consideration as an isolated event. It is the unintended emergence of a person on a lower level (cf. World Health Organization, 2008, p. 1, Balzer et al., 2013, p. 13). However, this gives rise to a number of further-reaching implications: The severity of the fall must first be professionally assessed. Decisions must be made to consult an external physician. If the patient is transferred to a hospital, a handover report with the most important key data of the resident as well as medically relevant facts such as the medication plan must be passed on. Relatives or representatives must be contacted and informed, and a bag with the most necessary personal belongings must be packed. Any planned visits to the doctor or physiotherapy sessions of the resident must be postponed or cancelled. Within the institution, the nursing management must be informed about the absence of the resident, as this can have an impact on the nursing home's financial claims against the cost units. The housekeeping staff must be informed in order to suspend the preparation of meals for the resident. The absence of a resident also changes the work schedule for the nursing staff, since capacities are now freed up at the responsible nurse. Finally, a fall protocol with an analysis of the course of events and the consequences must be drawn up. The phenomenon "fall", which is extremely condensed in terms of time and content, has extremely ramified and far-reaching consequences within the system.

The requirements for nursing professionals also include a large number of areas of competence which must be learned during the training. The Ausbildungs- und Prüfungsverordnung für die Pflegeberufe[5] (AltPflAPrV), which came into force on 1.1.2020, lists six areas with countless sub-areas which nursing professionals have to master. From the design and implementation of nursing processes and diagnostics to scientific skills (Annex 2, AltPflAPrV). It is striking that this new ordinance contains the terms "complex" and even "highly complex" 25 times. Trainees must prove in written examinations that they "have the skills required to care for people even in highly complex care situations" (§32 Paragraph 1) and "[t]he [practical] examination takes place in real and highly complex care situations. It covers the care of at least two people, one of whom has an increased need for care and a highly complex care situation" (§37 Paragraph 4)[6]. A definition of when such a care situation can be regarded as complex or highly complex does not exist in the regulation.

[5] Training and Examination Ordinance for the Nursing Professions
[6] Translation provided by the author

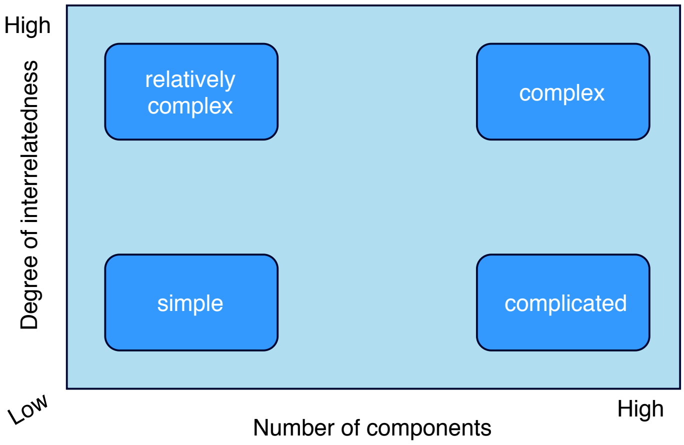


Figure 1.1: Differentiation of systems (after Braithwaite et al., 2017, S. 7)

However, it is clear that the legislature is aware that care takes place in situations that are not directly manageable or easy to control. In order to take this fact into account, the consideration and analysis must then also take place within a framework and with methods that are suitable to adequately capture this. **Complexity theory** is particularly suitable for this purpose.

“Complex” must be clearly distinguished from “complicated”’, even if in colloquial language both words are often used synonymously in the sense of “incomprehensible”’ (cf. Fellermann, 2003, p. 27). Both terms mean different things. The decisive factor here is the number of elements in relation to the two categories “components” and “interrelations” (cf. Braithwaite et al., 2017, p. 6). A system may, for example, consist of a small number of components that are hardly related or dependent on each other, such as a music box. By means of a crank, a pin roller is driven, whose pins cause the plates of the reed comb of different lengths to vibrate, thus producing the tones of the melody. Such a music box consists of a manageable number of components that are clearly related to each other: The crank turns the roller directly or possibly via a gear transmission. Depending on the direction in which it is turned, it also turns the cylinder accordingly. Each position of a pin of the roller actuates a reed, which always produces the same tone due to its length. The result is the always same melody when turning the crank. It is only influenced in a predictable way by the speed of the rotation. Such a system is called **simple system**. If the number of components increases, this also changes the system: The engine of a car consists, in comparison to a music box, of many different parts: Cylinder, V-belt, fan, alternator, etc. What both systems have in common, however, is that they operate in a predictable, logical manner. The same impulses produce the same reactions of the system. The V-belt driven by the engine will always run over the roller of the alternator in the same way, producing electricity for the car’s components. However, the high number of parts makes this a **complicated system**.
To describe the transition to **complex system** the connection of the components is crucial. In the previous examples these were connected sequentially and linearly. Impulses were passed through the system from component to component and thus triggered logical conclusions. In addition, they were independent of each other: Even if they are necessary for the existence of the system, their exchange does not lead to an influence on the overall system (cf. Glouberman et al., 2006, p. 329).

If you replace parts of the engine during maintenance, the car will run the same way afterwards. Complexity arises, however, when many individual parts of the system are connected to each other in multiple ways and their reactions can no longer be interpreted linearly. The individual components of the system and sometimes also superordinate structures from these parts as well as the basic rules according to which they can act are visible, but the resulting behavior remains hidden (cf. Braithwaite et al., 2017, p. 7). Complexity theory wants to explore this behavior and the interactions. Closely related to it is the concept of **Complex Adaptive Systems** (CAS), which additionally incorporates the factor of independent adaptation of a system to internal reactions and external influences. Such systems are a subset, respectively special form, of complex systems, whose functioning and characteristics will be presented in the following. They make it possible, as will be shown, to represent and understand the processes in the health care system and its facilities.

Complexity theory and the idea of complex adaptive systems is part of a tradition that ultimately goes back to Greek antiquity (cf. Holden, 2005, p. 651). The question has always been asked how phenomena function in their entirety, how things come together to form an overall picture, or, in the words of Goethe’s Faust, “whatever holds the world together in its inmost folds”. Such questions inevitably lead to systems theory, which forms the basis of complexity theory. In the 1950s Ludwig von Bertalanffy sketched a “General Systems Theory”’ in which he described systems as “a number of interacting elements[...]” characterized by different properties (cf. von Bertalanffy, 1972, p. 32)[7]. CAS also have intellectual roots in chaos theory, which is also based on systems theory (cf. Chaffee and McNeill, 2007, p. 232). From this theory, complex adaptive systems derive, among other things, the property of non-linearity. However, there is no clarity about how the exact relationship between chaos and complexity is to be represented (cf. Fellermann, 2003, p. 37). The only agreement is that the two are not identical (cf. Cilliers, 2002, p. IX, McDaniel and Driebe, 2001, p. 13). According to Cilliers, one of the distinguishing criteria is the number of interacting parts:

> *Chaotic behavior in the technical sense of deterministic chaos results from the non-linear interaction of a relatively small number of equations. In complex systems, however, there are always a huge number of interacting components (Cilliers, 2002, S. IX).*

Chaos theory naturally includes many other aspects and is by far not just a reduced version of complex adaptive systems. However, a more detailed presentation would not be helpful here for further understanding. It should be mentioned, that some authors such as McDaniel and Driebe consider chaos as a “subset of complexity”(McDaniel and Driebe, 2001, p. 13). So a connection between both theory complexes is definitely given. Since both are rather ambiguously defined and it is not clear what belongs unambiguously in which area, different views on different topics can be found in the literature.

The CAS were introduced by a working group at the Santa Fe Institute in New Mexico (cf. Chaffee and McNeill, 2007, p. 232), a “[...]Justice League of renegade geeks, where teams of scientists from disparate fields study the Big Questions”, as the Institute quotes a commentary by the Rolling Stone Magazine in its digital appearances. Pioneers in this field were John Holland and physics Nobel Prize winner Murray Gell-Mann. It is therefore not surprising that CAS emerged from the findings of quantum theory: There are interdependencies between electrons. The atoms and molecules react

[7] reprint of the original essay from Biologica Generalis of 1949 in German

to external influences and spontaneously reorganize themselves, which in turn influences the internal structure. This self-organisation does not follow any superordinate plan or goal (cf. Holden, 2005, p. 652). In a further step, these observations were transferred to biological conditions: swarm behaviour in birds and fish or the behavior of a shifting dune in the desert follows similar, fundamental laws as the atoms at the smallest level. This developed into a branch of research that increasingly spread across a wide range of disciplines such as technology, human and natural sciences or management and enjoys great popularity (cf. Fellermann, 2003, p. 25, Notarnicola et al., 2017, p. 4, Kappelhoff, 2003, p. 2). This is not least due to the fact that, according to Holland, many of the current problems are centered around complex adaptive systems (cf. Holland, 2006, p. 1). However, there is no consensus on what complexity is in detail and what characteristics CAS shares.

A uniform definition has been lacking since the development of the early 1990s. At that time, Gell-Mann complained that the different groups at the Santa Fe Institute had different views on a CAS and even the terminology differed (cf. Gell-Mann, 1994, p. 17)[8]. But even two decades later there is still no agreed definition of a CAS (cf. Notarnicola et al., 2017, p. 2). Complexity theory is rather an amalgamation of overlapping, different theories and disciplines than a uniform theory building (cf. Kappelhoff, 2003, p. 3/8,Chaffee and McNeill, 2007, p. 232). A consensus on what complexity means and how it is to be quantified would be of great advantage (cf. Fellermann, 2003, p. 27). Only with a measure of complexity at the interval or ratio level can meaningful classifications of systems be made. Whether complexity in an institution increases or decreases, for example, requires a tangible, operationalisable measure. Questions, which amount of complexity has which influence on a system can only be answered if there is an understanding of how complexity can be measured[9]. Notarnicola and colleagues have compiled six definitions alone from renowned scientists in this field (cf. Notarnicola et al., 2017, p. 2-3). What they all have in common is that they state a radical turning away from a **reductionist world view**. A Newtonian understanding of the world and its phenomena, which functions according to strictly causal and quantifiable laws, is not compatible with the findings of the observation of social systems (cf. McDaniel and Driebe, 2001, p. 23, Notarnicola et al., 2017, p. 1, Plsek and Greenhalgh, 2001, p. 625) and must therefore be overcome if research theory and methods is supposed to do justice to the subject. A dynamic, interdependent and unpredictable goal cannot be captured by mechanistic views. And just the health care system and its institutions correspond too exactly to this description to expect simple answers to complex questions (cf. Khan et al., 2018, p. 2). This is why Holland summarizes one of the "tasks" of complexity theory:

> *The traditional technique of reduction - studying the parts, then add up the parts' behaviors to get the behavior of the whole - does not work. The interactions as well as the parts must be studied (Holland, 2006, S. 3).*

As a basis for the further consideration of complex adaptive systems, four common features should serve as a basis, which John Holland lists:

- **Parallelism:** All agents send and receive simultaneously and in parallel, large amount of signals

[8]Linked to the anecdote that one scientist would rather use another scientists toothbrush than his terminology.
[9]Introduction to this topic: Fellermann, 2003

- **Conditional Action:** The action of an agent depends on the signals it receives
- **Modularity:** Within agents subroutines are formed, how to react to signals
- **Adaptation/Evolution:** Agents of a CAS change over time (cf. Holland, 2006, p. 1-2)

The parts of a system, called **agents**, are in constant communication with themselves and the environment. Their actions and interactions are parallel and never isolated from the information they receive from their environment. They form internal rules and control routines as they react to external or internal impulses and can adapt them to deal with the requirements and environmental factors. CAS search for regularities or patterns (cf. Gell-Mann, 1994, p. 18) in order to anticipate the future via internal models (cf. Holland, 1992, p. 24). The reactions are thus based on the expected outcome. In order to break down the functioning of a CAS, it is first of all important that, although they appear chaotic at first glance and exist (and operate) in a seemingly chaotic environment, a general pattern of action can always be identified (cf. Plsek and Greenhalgh, 2001, p. 627). CAS strive to recognize this regularity in order to then translate it into rules (Gell-Mann speaks of "schemes") for how to react to an external impulse (cf. Gell-Mann, 1994, p. 22). With this behavior, complexity can be reduced to a manageable level. Central to the work of complexity theory is therefore the study of patterns and relationships, not of objects, as in a mechanistic approach (cf. McDaniel and Driebe, 2001, p. 12).

The objects that make up a complex adaptive system are nevertheless important and must be considered. They are usually called agents and are "building blocks" of the system. Within a nursing home, housekeeping, facility management, the individual organizational units, cooperation partners, etc. are all part of the system. Of course, these do not exist atomically, but are themselves often again CAS with a multitude of their own agents. An organizational unit consists of a number of nursing staff with different qualifications. Just as a nursing home is an agent within a regional care network, which in turn is integrated into the healthcare system, etc. CAS can be seen as consisting of adaptive agents, which in turn are each their own CAS (cf. Gell-Mann, 1994, p. 23, McDaniel and Driebe, 2001, p. 15, cf. Kappelhoff, 2003, p. 4). They all do not stand in space unconnectedly, but are in constant relationship and reaction to each other. Their own behavior thereby arises from the interactions of the agents within the whole system (cf. Chaffee and McNeill, 2007, p. 233). As described, the agents strive to recognize **pattern** of their environment. They translate these into internal reaction patterns. If they receive an impulse, they react according to the self-defined **rules** to counter this context factor. The rules are not fixed, but change, which is the reason for the adaptive character (cf. Plsek and Greenhalgh, 2001, p. 626). Agents never overlook the entire system, but only parts of it (cf. McDaniel and Driebe, 2001, p. 15). This causes certain problems for the performance of the entire system and results in the difficulty in controlling such systems. Since all elements are interdependent, but their reactions also influence agents of the system about which they have no direct knowledge, undesirable and unpredictable results can occur. The overall system is unmanageable for both agents and researchers. This is not least due to the **large number** of elements within a CAS (Fellermann, 2003, p. 28, Holland, 1992, p. 19, Paley, 2007, p. 234, Notarnicola et al., 2017, p. 2). The individual agents on their part are very well understandable (cf. Paley, 2007, p. 237). However, their differences and their reaction to stimuli is also the decisive factor of adaptation and novel behaviour only made possible in the first place (cf. McDaniel and Driebe, 2001, p. 15).

While the overall system is characterized by complexity, the rules with which agents react to signals are characterized by simplicity (Holland, 2006, p. 2, Holland, 1992, p. 22, Gell-Mann, 1994, p. 18, Plsek and Greenhalgh, 2001, p. 627, Chaffee and McNeill, 2007, p. 234, McDaniel and Driebe, 2001, p. 17, Paley, 2007, p. 234). They are usually nothing more than **simple if-then mechanisms**. When a certain impulse is received, a reaction to it is stimulated according to the defined rules. In this respect the agents are no different from simple systems. The effects, however, are clearly different, since complex structures and behaviors emerge from these simple rules.

This is due to the fact that the compounds that make up the essential part of the consideration of a CAS are **non-linear** (McDaniel and Driebe, 2001, p. 12, Holden, 2005, p. 652, Notarnicola et al., 2017, p. 2, Fellermann, 2003, p. 28, Plsek and Greenhalgh, 2001, p. 626, Paley, 2007, p. 236). This means that the output of an agent, which, processed by the simple, intrinsic rules, is triggered by an external impulse, can have far-reaching consequences within the system. Given the interconnectedness of many agents, even the smallest changes can have a big impact. The outcome is thus not directly attributable to the action of one agent, but arises only through the interaction and co-reaction of other agents (cf. Khan et al., 2018, p. 2).

This means that CAS and its agents are highly context-bound. Part of the context is the already mentioned fact that CAS are partly agents of higher-level systems. They have a hierarchical, nested relationship to each other, or are subsets and supersets of each other (cf. Chaffee and McNeill, 2007, p. 233, Gell-Mann, 1994, p. 23, Notarnicola et al., 2017, p. 2). The change of a single CAS can therefore mean that there is also a change of a superordinate system whose agent is the CAS. This means, as it were, that the whole cannot be viewed and understood without understanding the parts and the parts cannot be viewed and understood without understanding the whole (cf. Chaffee and McNeill, 2007, p. 234).

All points discussed are currently only factors of a complex system. CAS differ, however, in their ability to adapt to their environmental influences and stimuli (cf. Paley, 2007, p. 236). This is possible because they constantly collect information about their environment and about themselves (cf. Gell-Mann, 1994, p. 18) in order to be able to react accordingly. This process of **Adaption** includes an independent reorganization in order to adapt to the problems posed (cf. Holland, 1992, p. 18). The agents and their interaction, triggered by the agents intrinsic rules, change their behavior due to requirements that cannot or only insufficiently be met (cf. Holland, 1992, p. 25). They are so to speak “capable of learning” (cf. Notarnicola et al., 2017, p. 3). However, their memory is not readable, but takes place in the form of reaction schemes as a result of an adaptation from previous experiences (cf. Gell-Mann, 1994, p. 18). Christopher Langton, also involved in the formation of a theory of complex adaptive systems at the Santa Fe Institute, attributes this adaptation to the position of the system at the edge of chaos in an earlier workshop (cf. Langton, 1989): Systems do not have enough certainty and agreement that the reactions are predictable, as is the case in simple systems; for there the reaction from the impulse can be logically predicted. However, they are also not chaotic enough for their reactions to be purely arbitrary. Adaptation becomes necessary in order to not to fall into chaos. What is a good and what is a bad result of adaptation is often not easy to grasp. For clarification, the understanding of the system itself can be used as an example: With the mechanistic model the scientific community had found a way to reduce seemingly arbitrary influences in their complexity and to show an overriding pattern. Individual parts were regarded as connected with each other in certain causal chains of action. The agents of the system, scientists or

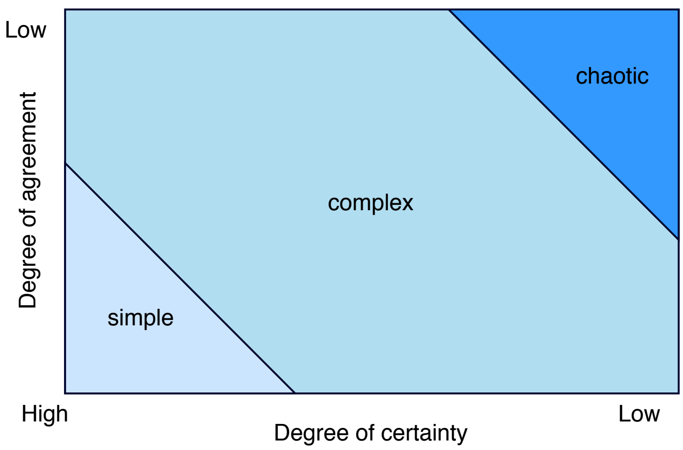


Figure 1.2: Certainty-aggreement diagram (after Stacey, 2011)

universities, developed rules that were designed to predict future “events”, cases, etc. For the reasons already mentioned, however, this reached a limit. Explanatory models were no longer sufficient to understand the phenomena and reality did not correspond to the patterns that had previously been used. Thus, the system increasingly moved towards chaos (cf. figure 1.2). To avoid this drift, complex adaptive systems have the ability of **self organization**. Already the development of their own rules and the networking of agents among themselves are such self-organizing processes (cf. Chaffee and McNeill, 2007, p. 234, Fellermann, 2003, p. 28, Anderson et al., 2003, p. 2). It is a necessary prerequisite for adapting to the changing internal and external influences, and thus for being adaptive. System theoretical considerations, for example, offer a more consistent approach to understanding systems in their complexity and are thus superior to the mechanistic approach in terms of its ability to process impulses. The scientific community has thus changed its focus for social systems and can now predict events or behavior much better.

However, scientific theories in particular also offer a wealth of examples of maladaptation (cf. Gell-Mann, 1994, p. 23). Over centuries, people have developed theories and views on the origin, transmission and significance of diseases. From the workings of evil spirits, to divine punishment or bad juices, various theories offered ways to process and predict reality. However, a stringent further development towards the “right” in the sense of a linear improvement is obviously not necessarily given. This is also related to the interdependence of the agents of a CAS. If an agent changes its set of rules “for the better”, in the sense of a better adaptation, then it influences all other agents as well. This can lead to the failure of their positive coping routines, which in turn can lead to problems for the entire system (cf. Plsek and Greenhalgh, 2001, p. 626). If, for example, in a nursing home it has been introduced that breakfast is not served until 9 a.m. to allow all residents and nursing staff to work more relaxed in the morning, this can mean that kitchen staff has less time to prepare lunch. As a result, working hours may have to be moved later in the afternoon. This can lead to problems with childcare for parents who work part-time, etc. A positive adaptation of one agent, can therefore lead to the overall system changing for the worse. An optimal, global solution can therefore hardly be achieved through these tensions (cf. McDaniel and Driebe, 2001, p. 21, Holland, 1992, p. 19).

CAS also exist in a “fitness landscape” (McDaniel and Driebe, 2001, p. 21): Adaptations of a sys-

tem also influence surrounding CAS (cf. Plsek and Greenhalgh, 2001, p. 626). For example, the opening of a new, modern nursing home in the surroundings of an old facility can lead to senior citizens deciding against the outdated home. The latter comes under pressure to adapt due to the change and may seek to renovate or change the care concept in order to remain competitive. This common change of a CAS in itself and in the structure with other CAS is also called **coevolution** (cf. Kappelhoff, 2003, p. 2, cf. McDaniel and Driebe, 2001, p. 20).
These adaptations are to be distinguished from simple or direct adaptations. Cybernetics, for example, is also familiar with adapting systems and they are often used in the fields of industry and technology (cf. Gell-Mann, 1994, p. 20). Gell-Mann uses the image of a heating thermostat which soliloquy-like compares the incoming information (ACTUAL temperature) with the value to be achieved (TARGET temperature): "Too cold, too cold, too cold, just right, too warm, ..."' and accordingly triggers a simple reaction to it (heating ON/OFF).
The reactions of complex adaptive systems, on the other hand, are much less comprehensible in their effects and, in addition, have **no central control** (cf. Holland, 1992, p. 21, Paley, 2007, p. 235, Chaffee and McNeill, 2007, p. 233, McDaniel and Driebe, 2001, p. 15/18), which is an essential feature of these systems. Central control seemed to be obviously given for many complex adaptive systems in nature: a controlling, superior element that guides development and sets the direction. For a long time, this had been assumed for example for the swarm behaviour of fish or birds. However, these do not follow a "leader", but a small set of simple rules to achieve their goal. Similarly, in all other CAS, no single entity defines the goal to be achieved, but rather it establishes itself as a pattern from the incoming information and the urge to anticipate the future from the previous circumstances and rules.
Adaption, in conjunction with non-linearity, is also the trigger for **Emergence**, the formation of new properties from the interaction of different parts. Through the connection of the agents with each other, properties of the system are created that cannot be traced back to the abilities or behaviour of the individual agents (cf. McDaniel and Driebe, 2001, p. 18, Khan et al., 2018, p. 2). Due to the vagueness of understanding of the system for its parts, however, it cannot be controlled concretely (cf. McDaniel and Driebe, 2001, p. 18), which makes a targeted steering of a CAS difficult. Likewise, emergent properties can also have a negative effect on the overall capability of a system.

Understanding, controlling and researching complex adaptive systems is very difficult in practice. They are often referred to as "moving target" (cf. Holland, 1992, p. 18, McDaniel and Driebe, 2001, p. 22), which is difficult to grasp because of its dynamics, the constant reorganization of its agents and the fragile boundaries, where agents can be members in several systems at the same time (cf. Plsek and Greenhalgh, 2001, p. 625, Fellermann, 2003, p. 28, Chaffee and McNeill, 2007, p. 235). Therefore, a special handling of CAS is necessary in research projects. Up to now, the previous theoretical knowledge on complexity theory could often not be sufficiently translated into practical action (cf. Plsek and Greenhalgh, 2001, p. 625, McDaniel and Driebe, 2001, p. 14). This was not least due to the fact that adequate methods were not available for this purpose (cf. section 1.4). Paley mentions observation as the crucial way to understand what exactly a CAS will do. Predictions are not manageable due to the structure and the fact that even the agents do not have a comprehensive knowledge of the interrelationships (cf. Paley, 2007, p. 237). This level of complexity can never be completely mastered. The goal is merely to break it down to a manageable level (cf. Khan et al., 2018, p. 7). However, a certain amount of irreducible uncertainty always remains. Therefore, standardization remains limited to the areas of lower complexity. For even if the term complex adaptive systems is used more and more frequently (and perhaps more inflationary), it must still be emphasized, despite all definitional ambiguity: Not everything is a system, not all systems are complex, and not all complex systems are adaptive (cf. Paley, 2007, p. 240)!

There is a whole range of authors for nursing and its institutions, who shed light on why these areas are complex adaptive systems (for example: cf. Holden, 2005, p. 652, McDaniel and Driebe, 2001, p. 11, Paley, 2007, p. 233, Notarnicola et al., 2017, p. 7, Khan et al., 2018, p. 2).
Early nursing theorists such as Jacquelin Fawcett had already tried to take a comprehensive view on nursing in their work. The nursing action was embedded in the relationship of the nurse to the patient, who in turn are both involved in their own contexts. This comprehensive view is therefore by no means uncharted territory for nursing (cf. Holden, 2005, p. 655). Nursing ideals such as wholeness and patient-centeredness are further factors that underline the complexity of the system. A joint decision making in the treatment process, which takes into account the wishes and views of the patient, creates new, more complex interactions between the actors than a view of him as a subordinate "recipient" of a uniform, professional service (cf. Khan et al., 2018, p. 2). The nevertheless still existing informational asymmetry between practitioner and patient is also an aspect which is the cause of far-reaching interdependencies (cf. McDaniel and Driebe, 2001, pp. 11f.). And also interprofessionalism (cf. Khan et al., 2018, p. 4) as well as heterogeneous intraprofessionalism (cf. McDaniel and Driebe, 2001, p. 12) cause a plethora of connections on the most diverse levels within the care system, which enormously increase its complexity.
Therefore, there are good reasons to regard nursing homes as complex adaptive systems. However, to cope with the complexity there, tools are needed that can capture dynamic, non-linear and emergent properties (cf. Khan et al., 2018, p. 6). Organizational research which incorporates complexity-theoretical considerations and neo-configurational thinking, offers an approach to this. Since complexity theory promotes thinking in supersets and subsets of systems, agents, etc., it fits into the approaches of Qualitative Comparative Analysis, which will be applied in the further course.
First, however, organizational factors are regarded as information-rich factors of an institution.

1.2 Organizational factors in nursing homes

Organisational factors are one way of defining and distinguishing facilities. All attributes of an institution that relate to the structure, equipment and design of a nursing home should be regarded as such. These include, for example, aspects of **location and architectural features**: In which federal state an institution is located, whether it is in an urban or rural region, how many buildings and organizational units[10] it includes, how much built-up area, or the year of construction and the last renovation. In addition, the offer of specific **care areas and services**, for example for ventilated residents or residents with dementia. Also questions of quality and quality assurance, in the form of certification, care for relatives and volunteers or cooperation with external service providers

[10]This term is used generally for any division of the residents within the institution: stations, living areas, living groups, floors, etc.

(specialists, pharmacies, hospices, specialists etc.) represent organizational factors. A further area covers the topic of **conception of care**: care concepts and theories, documentation procedures or a home-like unit concept. The **staffing situation** is equally important for the organizational structure of a nursing home. The composition according to full-time and part-time employees, qualification levels, the scope of positions in functional positions such as quality management, nursing management or mentorship and parameters such as hours of illness, vacant positions, etc. can be used to characterize an institution.

These factors can be distinguished with regard to their **expression of internal and external structures** of the respective home. External structures are those which are directly visible: Size of the facility, number of rooms, location in the geographical area, specialized living areas, etc. In contrast, structures which are not directly perceptible are referred to as "inner": These attributes in their different manifestations fulfill, in combined form, the requirements for an **organizational configuration**, as defined by Meyer et al. 1993: "[...]any multidimensional constellation of conceptually distinct characteristics that commonly occur together" (p. 1175).
However, it is by no means guaranteed that every combination of attributes also occurs or can occur empirically. They are limited by a wide variety of influences (cf. Meyer et al., 1993, p. 1176). Danny Miller was a pioneer in the description of such steering forces with his work "The genesis of configuration" in 1987. He describes the four imperatives **environment, structure, leadership and strategy**, which predominate as structuring elements in organizations and direct the expression of the individual factors in certain directions (cf. Miller, 1987, p. 686).
The **environmental imperative** states that organizations adapt to external influences: Customer reactions and competing companies force an organization into certain trajectories to remain successful and viable (cf. ibid., p. 688). Thus, outstanding concepts (and thus also organizational factors) can indeed be a unique selling proposition; but if they do not satisfy the needs of the customers, or if they are perceived as deficient compared to the competition, they can endanger the existence of an organization.
An institution subject to the **structure imperative** concentrates on internal processes with the aim of optimizing them and thus positively influencing decision-making, performance, efficiency and reliability. There is a specific, self-reinforcing arrangement of elements that harmonize with each other in a special way to achieve this result (cf. ibid., p. 691). This also limits the variability.
In a **leadership imperative** the arrangement of the organizational factors is strongly coupled with the goals, ambitions and ideas of a leader. This is possible above all in young, still relatively small companies, since the complexity that arises can be dealt with centrally by one person or a small circle (cf. ibid., pp. 693f.). A positive or negative development can thus be directly attributed to an individual's decision. The connections between impulse and shaping of the system thus tend to be linear. With increasing organizational complexity, however, this imperative no longer applies, as it is not sustainable in the long term. In such a system, centralization on one person cannot ensure permanent existence.
The **strategy imperative**, on the other hand, focuses on a business concept or other explicit strategies as the core element for organizational design. The serving of market niches or the orientation towards proven, successful business models guides the design of an organization (cf. ibid., pp. 695f.). Not all of these concepts are viable, so companies may need to reorient themselves accord-

ingly in order to remain economically viable. Here there are cross-connections to the environmental imperative.
Of course, these imperatives rarely occur in institutions in the pure form shown, but often form the basis of the organizational design in hybrid form.

In this section, a selection of limiting factors will now be shown in concrete terms which nursing homes "prevent" from empirically shaping certain constellations of characteristics. These influences can be divided into the three areas: Legal framework conditions, management influences and regional differences.

Legal framework conditions account for the largest share of the influences found. They represent a supplement and extension of the Millerian environmental imperative. The federalist structure in Germany makes it possible for each federal state to draw up its own legislation with regard to the design of the regulations on nursing homes. As part of the federalism reform of 2006, the regulatory regulations became the responsibility of the federal states. Only civil law regulations are regulated by the federal government (cf. Simon, 2013, p. 535). Because of this variability in legislation, the following section looks at the currently valid (as of 2020) legal situation in the state of Baden-Württemberg, since that is also where the data used later originates from (see chapter 4). The BIVA-Pflegegeschutzbund[11] names five relevant laws and regulations for Baden-Württemberg, which concern the organisation of institutionalized care[12]:

1. Wohn-, Teilhabe- und Pflegegesetz[13] (WTPG)
2. Landesheimmitwirkungsverordnung[14] (LHeimMitVO)
3. Verordnung des Sozialministeriums zur baulichen Gestaltung von Heimen und zur Verbesserung der Wohnqualität in den Heimen Baden-Württembergs[15] (LHeimBauVO)
4. Landespersonalverordnung[16] (LPersVO)
5. Rahmenvertrag vollstationäre Pflege[17]

The **WTPG** regulates thereby in § 10 the requirements for operation. It sets conceptual minimum standards for the care institutions that concern personal aspects of the resident, such as the preservation of dignity and independence, respect for religious, cultural and sexual orientation or integration into society (§10.2 sentences 2-4, 7, 8). In addition, there is the safeguarding of professional standards by the institution and protection against errors in care and treatment (§10 Paragraph 2 Sentences 1, 5, 6, 11, 12), as well as pragmatic requirements, such as ensuring an appropriate housing situation, documentation of assistance plans or compliance with legal regulations (§10 Paragraph 2 Sentences 8, 10, 13).

[11] BIVA-care protection association
[12] `https://www.biva.de/gesetze/laender-heimgesetze/`
[13] Housing, Participation and Care Act
[14] State Participation Act for Nursing Homes
[15] Regulation of the Ministry of Social Affairs on the structural design of homes and the improvement of the quality of living in the homes of Baden-Württemberg
[16] State Staffing Act
[17] Framework agreement for full inpatient care

These requirements form the "basic framework" of every institution, which cannot be undercut by law. Building on this, each institution then has a personalized structure for the individual points, which can be different in each case. Because the law only formulates goals but no measures (at this point), ways of safeguarding privacy or gender-specific concerns can, for example, be very different.
The **framework agreement** between the cost bearers, the Medizinischer Dienst der Krankenversicherung (MDK) and the service providers of full inpatient care in Baden-Württemberg regulates in a similar way the concrete, content-related services of care provided by institutions. These must comply with the requirement of economic efficiency in accordance with §29 SGB XI and are laid down for each German federal state in a separate framework agreement with the relevant players. This includes assistance in the areas of personal hygiene, nutrition, mobility, personal lifestyle, social care and medical treatment in the nursing field (§1 Para. 3), respectively supply and disposal, cleaning, maintenance and upkeep, laundry services, food and drink supply and community events in the case of domestic services (§2 Para. 2).
The **LHeimMitVO** regulates concretely the design of a home advisory board, through which the residents can influence the decisions of the nursing home (§1.1). In times, in which no home advisory board can be formed, an advocate committee is to be furnished (§ 11), or, if also this is not possible, at least one home advocate is to be appointed (§ 12). However, a representation of the residents' interests of any kind must be found in every nursing home.
In the **LHeimBauVO** very concrete statements are made about the structural characteristics of a facility and thus influence the empirical expression of the organizational factors. For example, the number of 100 home places at a location should not be exceeded (§2 Para. 2) and the facility should be located as centrally as possible within the municipality or district (§2 Para. 3) in order to be able to fulfill its function as a residential home (§1 Para. 2). In addition, single rooms must be provided for all residents who have a minimum size of 14 square metres (§3 paras. 1, 2). The structure of the facility must allow for the formation of small "apartments" or "housing groups" of a maximum of 8 or 15 persons (§4 Para. 1), which have communally used areas (§4 Para. 2). In addition, an independently accessible outdoor area must be provided (§4 Paragraph 5).
Finally, the **LPersVO** regulates a number of minimum personnel requirements for the homes, which have a concrete influence on the design on site. On the one hand this is done for the management functions: For example, if the number of residents exceeds 90 persons, 1 full-time equivalent must be provided for the management of the facility (§3 Para. 2). The position of a nursing management for this purpose should not have less than 0.5 full-time equivalents, but should normally be covered by one full-time equivalent (§6 Paragraph 3). On the other hand, the ordinance also regulates the remaining qualified personnel. Their minimum quota is deemed to be met if it is at least 50% (§8, Sub-Clause 1) or the number of non-trained nurses is less than 40% and at the same time the quota of registered nurses is over 40% (§9, Sub-Clause 1). If special care services are provided in the facility, such as ventilation care, at least one specialist with appropriate further training must be employed in the nursing home (§11). In daytime service, one registered nurse must also be assigned to 30 residents when drawing up the duty roster (§8 Para. 2), in night time service this applies to 45 residents (§10 Para. 1). For housekeeping, a corresponding specialist is prescribed for a number of 30 residents or more.

In almost all of these areas, and especially in the building sector, there are exceptions or inventory protection, as well as transition periods for the facilities, which increases the empirical diversity, despite the laws and regulations.

Regional differences between the federal states result, among other things, from the system of federalism and the accompanying different legal arrangements (see above). The **remuneration of the cost units** to the nursing homes themselves is also regulated decentrally. The daily rate, which can be charged per resident within a degree of care by the home, is determined in care rate negotiations (cf. Simon, 2013, p. 558). This can lead to sometimes considerable differences in individual remuneration. Diagram 1.3 is based on the figures of the Federal Health Report 2017. The Saarland negotiated the highest average nursing rates nationwide, while structurally weak regions in eastern Germany such as Sachsen, Thuringia or Mecklenburg-Western Pomerania are clearly behind. The daily rate for board and lodging (in the diagram: “B+L”), which is independent of the degree of nursing care and which home residents have to pay for themselves, is, for example, 10€ lower in Saxony (17.20€) than in the Saarland (27.20€).

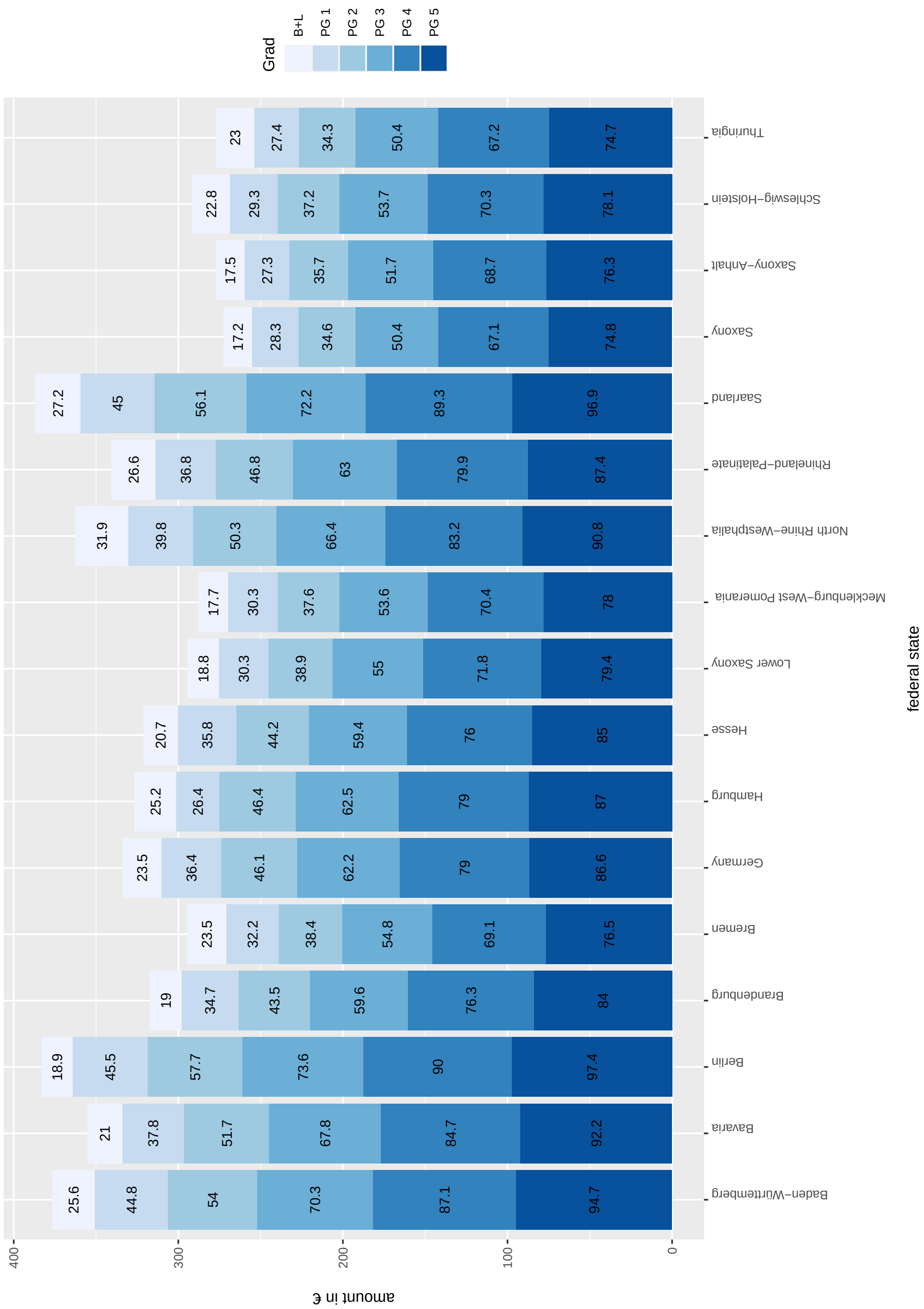


Figure 1.3: Average daily compensation per resident in € per Pflegegrad (PG) and federal state (2017) (own diagram after data of the "Gesundheitsberichterstattung des Bundes")

A facility there thus has 3405.20€ less financial means per year and resident for accommodation and care alone. In relation to the degree of care, the remuneration is about 24-40% below the Saarland values. Of course, this can also be attributed to different infrastructural and social conditions in the individual federal states. For example, the average monthly cost of living in the "new" federal states is still about 500€ below that of the western states[18], which makes living and housing in these areas considerably cheaper. This means that facilities can provide their residents with the same level of care with fewer resources.

One of the main cost factors on the nursing home side is personnel costs (cf. Rondeau and Wagar, 2016, p. 101). They too, and conversely the **wage levels**, differ between the federal states. Structurally weak regions consequently bring up the rear. The statistical offices of the Federal Government and the federal states calculate an average wage of 35.229€ per employee for Germany. Saxony and Thuringia are on average about 5300€ below this [19]. Lower wage expenditure is therefore also reflected in the lower nursing rates.

However, this does not apply to all federal states: while Berlin, Bavaria or Baden-Württemberg have relatively high wage costs on average and also tend to receive high rates of long-term care for residents, the Saarland, for example, is at the top of the long-term care rate table, although its wage level is below the average for the Federal Republic of Germany. Although the share of personnel costs can certainly be in the range of 75% of total costs [20], there is a clearly positive deviation of the two figures from each other here.

An explanation for this and thus a further factor can be the **structure of funding agencies** of the region. In Germany a distinction is made between public, non-profit and private carriers. With 4.8% (as of 2015) public homes make up the smallest share of nursing homes nationwide. The majority of the facilities are in non-profit (53%) or private ownership (42.2%) (cf. von Hirschberg et al., 2018, p. 24). These shares vary regionally. While public institutions are increasingly operated in the south of Germany (10% in Bavaria, 7.7% in Baden-Wurttemberg), public homes play virtually no role in the north (2.3% in Brandenburg, 2.5% in Lower Saxony (cf. ibid.)). Looking at the average compensation per Pflegegrad for homes with different funding agencies, diagram 1.4 results.

[18] https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Einkommen-Konsum-Lebensbedingungen/Konsumausgaben-Lebenshaltungskosten/Tabellen/liste-gebietsstaende.html

[19] https://www.statistik-bw.de/VGRdL/tbls/tab.jsp?rev=RV2014&tbl=tab11&lang=en-DE#

[20] https://www.bwkg.de/daten-fakten/statistik/kostenstruktur/pflegeheime/

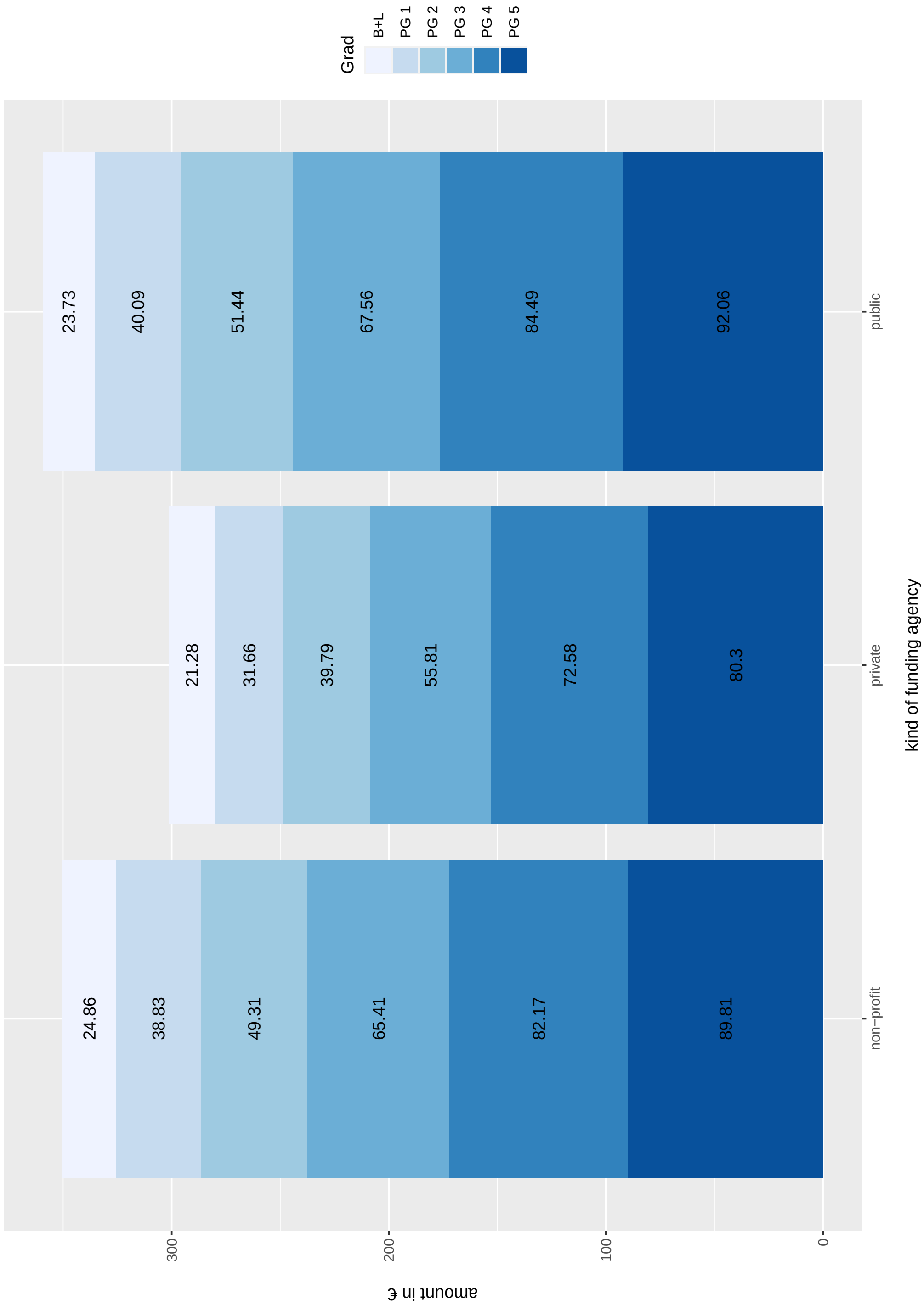


Figure 1.4: Average compensation in € per Pflegegrad (PG) and funding agency (own diagram after data of the “Gesundheitsberichterstattung des Bundes”)

It is shown that private institutions can negotiate significantly lower care rates for their residents than, for example, non-profit or public providers. Saarland, Baden-Württemberg and North Rhine-Westphalia each have over 60% of non-profit organisations, which is a strong characteristic and at the same time clearly above average nursing rates. It can be assumed that if a provider unites many facilities in one federal state, it has a much better basis for negotiation. This would also explain the relatively low nursing care rates for Thuringia or Saxony-Anhalt, where no clear structure of funding agencies prevails in the state (Thuringia: 35.5% private, 56.2% non-profit, 8.3% public and Saxony-Anhalt: 44% private, 49.2% non-profit, 6.8% public).
Another regional factor for the organizational design can be the **market concentration** on site, i.e. the competitive pressure between care providers. Accordingly, a high regional density of nursing homes leads to a large market offer and a diversification of services. The companies therefore come into competition for potential clients and are forced to differentiate themselves in their offers. Opportunities for this unique position can be efforts to improve the quality of services or to lower prices in order to increase customer benefits.
A study by the Bertelsmann Foundation shows that Brandenburg, Thuringia, Rhineland-Palatinate and Bavaria in particular have a very unique power of providers. Here, in 29 districts, the three largest providers concentrate more than 50% of resident capacity on themselves, which induces a dominant position (cf. Klein et al., 2016, p. 37). By contrast, in North Rhine-Westphalia or Saxony potential customers have a much greater power position vis-a-vis the providers, since the nursing home structure is much more diverse here, which means that companies have to invest more in attractive offerings.

Directly related to the legal framework and regional conditions, **decisions of the management** set the course for the design of organizational factors. They reflect Miller's leadership and strategy imperative. The attractiveness of offers in competitive situations, as described above, is a control variable that facility managers and management personnel in facilities can influence in order to set themselves apart from other homes. For example, special nursing areas can be created for residents in a coma vigil or on ventilation, certification by independent bodies can attest to particularly good nursing quality, or firm cooperation agreements can be concluded with other health service providers. More recently, digital aids have also been introduced to make the facility more attractive. The BeneVit Group operates more than 30 facilities in regions with a rather high market concentration [21] and the associated competition. It provides an app that relatives can use to access nursing reports, medication schedules, or the like and to get in contact with the nursing staff [22]. For cooperation with doctors and pharmacies, there are also applications available that enable direct communication with nursing staff and offer options for uploading medication plans and prescriptions directly into the documentation system. Such instruments increase the attractiveness and loyalty to the company for relatives, employees and partners in the health care sector.

The framework contracts for nursing care mentioned above also allow flexible **staffing corridors** within which the proportion of nursing staff to residents of a certain degree of care may vary. As of 1.3.2020, the upper limits for Baden-Württemberg have changed, following the arbitration award

[21] Comparing the locations (https://benevit.net/standorte/) with figure 17 from (Klein et al., 2016, p. 36)
[22] https://benevit.net/apps/

Table 1.1: staffing corridors Baden-Württemberg and percental change

	from 1.3.2017		from 1.3.2020		
Pflegegrad	lower border	upper border	lower border	upper border	change in %
PG 1	1:6,11	1:4,47	1:6,11	1:4,37	1,9
PG 2	1:4,76	1:3,49	1:4,76	1:3,4	2,6
PG 3	1:3,26	1:2,47	1:3,26	1:2,41	2,4
PG 4	1:2,55	1:1,9	1:2,55	1:1,84	3,2
PG 5	1:2,32	1:1,72	1:2,32	1:1,67	2,9

of 23.2.2017, as shown in table 1.1 (cf. Verband Deutscher Alten und Behindertenhilfe e.V., 2017, p. 2).
The accountable managers thus have a range within which they can deploy personnel for their facilities. This depends on their resident structure. Starting from a resident composition with regard to the degrees of care of:

- PG 1: 3 persons
- PG 2: 28 persons
- PG 3: 26 persons
- PG 4: 24 persons
- PG 5: 19 persons

the lowest possible amount is 31.95 full-time equivalents. The upper limit results in 42.9 (2017) and 44.13 (2020) and thus more than 10 full-time equivalents or 34%, respectively 38%, more staff than in the worst-possible scenario[23]. This allows for very different care keys or staffing levels within a federal state between the facilities, which influence the design of resident care.
However, these differences can also be designed at a social care level, which is often incorporated into the **concept** of an institution. Cooking together in the residential units instead of a central kitchen or involving the residents in household tasks such as ironing and folding laundry are a renunciation from the "traditional" centralised home organisation, which is often a pure service structure with all tasks being taken over. Other nursing homes are making their mark by offering activities for special groups of residents such as men. These are particularly left behind by the female-oriented activity offers in the nursing homes (cf. Müller-Hergl, 2010, p. 29f.). For this reason, for example, the "Haus St. Elisabeth" in Netphen (Siegerland) set up a "beer parlour" in which men can meet in the atmosphere of an old pub to drink beer and get in contact with each other (cf. Schwab, 2011), in order to be able to take better account of biographical circumstances.

In summary, both **rigid and flexible** influences can be identified, which influence the organization of the nursing homes. They stretch out a spectrum within which there is room for an individual

[23]calculation based on the presentation 'Personnel assessment in inpatient nursing care. What is the basis of staffing in the shift" of the DBfK. Available from: `https://www.dbfk.de/de/expertengruppen/pflege-in-stat-pflegeeinrichtungen/PPP-Personalbemessung-Praesentation-2018-06-29-final.pdf`

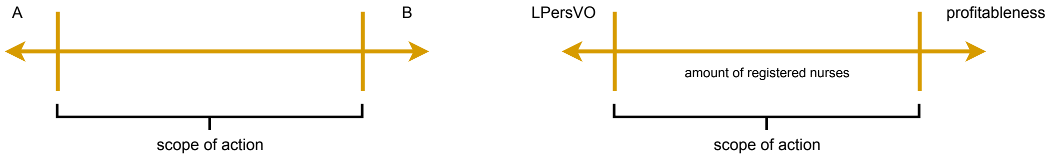


Figure 1.5: Limited scope of action with organizational factors

shaping of a facility. This explains the configurations one finds in reality.
In concrete terms, the number of nursing staff within an institution would be limited on the one hand by the provisions of the state personnel ordinance, which stipulates that one registered nurse must be available for every 30 residents or that they must make up at least 40% of the staff (§8 Para. 2 and §9 Para. 1 Sentence 3). On the other hand, as a management influence, profitability limits the number of nursing staff. Only a certain proportion of the available budget can be allocated to these personnel costs, without other interests or obligations having to be weighed against them (investments, formation of reserves, profit, maintenance ...). The reasons for how organizational factors are structured in reality are therefore complex and multi-causal. The influences they have on the institution "nursing home" can therefore be no less trivial. In order to do justice to this interaction of multi-causal factors within a system, the view of causal complexity has become established.

1.3 Causal complexity

Reality and social phenomena are undoubtedly complex. And apparently so much, that the Chinese philosopher Zhao Tingyang, for example, distances himself completely from them:

Die Wirklichkeit ist viel zu kompliziert und zu detailreich. Ich habe nicht genug Informationen darüber, was passiert. Selten gehe ich nach draußen. Ich halte also Abstand zur Wirklichkeit[24]. [25]

A final definition can hardly be found for many aspects of the social reality, due to their incomprehensibility (Braumoeller, 2003, p. 210). Also the causalities of these phenomena are complex, because they themselves are extremely diverse (cf. Ragin, 2000, p. 93). Social science research, however, enters this complexity by definition and must therefore find ways to become aware of it and to handle it. Thereby also the context of a phenomenon always plays a decisive role. The individual parts cannot and must not be regarded in isolation but within their environment in which they are embedded. The changing of a partial aspect can thereby change the understanding of the whole, which in turn changes the view of the individual (cf. Ragin, 1987, pp. 23f.). The funniest joke, conceived as an encouragement, cannot cause laughter in an inappropriate situation. And whoever has made it is then not perceived by his environment as a joker, but as insensitive. Phenomena such as humour, but also burn-out, job satisfaction or quality of care can hardly be explained by a single factor. A high workload may be a decisive reason for burn-out, but bullying by colleagues, lack of recreation at home or fear of the future can also play a role. The state of health of the residents can be a factor influencing quality in a nursing home. But it can also be the subjective satisfaction of the residents, the staffing or the leisure activities. One cannot assume that **one** aspect of this can be

[24] The reality is far too complicated and too detailed. I don't have enough information about what's happening. I rarely go outside. So I keep my distance from reality.

[25] `https://www.deutschlandfunkkultur.de/zhao-tingyang-alles-unter-dem-himmel-weltfrieden-auf.1270.de.html?dram:article_id=468415`

picked out and identified as the sole valid, causal reason, because "social phenomena typically result from a combination of conditions, and very often the same outcome will result from several different combinations"' (Ragin, 2000, p. 99). This situation is called **causal complexity** (cf. Braumoeller, 2003, p. 210, Ragin, 2008, p. 124).
According to Braumoeller, it is characterized above all by conjunctive causality and interchangeability of arguments (cf. Braumoeller, 2003, p. 211). In the context of Qualitative Comparative Analysis and quantity-theoretical methods, authors refer to this interchangeability as equivalence and add asymmetry as a characteristic. These three components of causal complexity

- **Equifinality** (cf. Berg-Schlosser et al., 2009, p. 9, Kahwati and Kane, 2019, p. 10, Mahoney, 2008, p. 424,Schneider and Wagemann, 2012, p. 78,Ragin, 2008, p. 54,Ragin, 1987, p. 25)

- **Asymmetry** (cf. Berg-Schlosser et al., 2009, p. 9, Kahwati and Kane, 2019, p. 11,Schneider and Wagemann, 2012, p. 78,Caramani, 2009, p. 68)

- **Conjunctural causation** (cf. Berg-Schlosser et al., 2009, p. 9, Kahwati and Kane, 2019, p. 10f.,Schneider and Wagemann, 2012, p. 78,Caramani, 2009, p. 65, Ragin, 1987, p. 25)

are outlined below.
Equifinality is a concept that allows several possible explanations for a phenomenon. As described above, social reality is too complex to be reduced to a single, causal factor. Equifinality, on the other hand, allows for all models that are capable of explaining the examined outcome. Many different paths can therefore lead to the same result. These stand, with regard to their validity, equally next to each other and are usually called "logical equivalents" (Ragin, 1987, p. 25). The contrary principle would be unifinality, which would only seek a single, "optimal" solution. Kahwati and Kane use the very vivid comparison of a chocolate cookie recipe for this purpose: An equifinal approach would be to collect all recipes for chocolate cookies and let them exist side by side as equal solutions for baking these cookies. Unifinal approaches, on the other hand, would try to make a single "optimal" solution from the information on the quantity of flour, eggs, baking powder and chocolate of the individual recipes (Kahwati and Kane, 2019, p. 10).
Asymmetry describes the condition that in the investigation of phenomena the occurrence and absence of the corresponding outcome are two independent circumstances with regard to causality. The absence of the outcome cannot therefore be assumed to be the reversion of those factors which are responsible for the occurrence of the outcome. Rather, the triggering factors can be completely different. In the same way, the found solutions only apply to the corresponding expression of the outcome, not to its negation. Reasons for job satisfaction (Y) could be, for example, payment (A), appreciation (B) or the opportunity for professional development through further training (C). Conversely, the absence of the factors A-C does not necessarily mean that you do not feel satisfied in your job. Rather, quite different reasons can play a role, such as a poor working atmosphere (D) or high levels of absenteeism among colleagues (E). Therefore, both situations, the occurrence and non-occurrence of outcome Y, must be considered and analysed separately in terms of content.
Conjunctural causality describes situations in which single factors alone have no direct effect

on the outcome. Their presence or absence alone does not change the outcome. Only in interaction with others do they develop an effect. For example, payment as a factor cannot be an aspect for lasting job satisfaction. It is only in connection with appreciation that satisfaction is created. Conversely, appreciation is also only decisive in connection with payment. This way of thinking breaks up the concept of additivity (cf. Berg-Schlosser et al., 2009, pp. 8f., Braumoeller, 2003, pp. 211). Variables are not regarded as individual, independent influences, each of which influences the outcome separately, but only through a combination of common presence and/or absence. However, formally speaking, this is not an interaction effect either (Kahwati and Kane, 2019, p. 11f.), since the variables under investigation do not necessarily influence each other in their manifestations, but can also be independent of each other. This approach to causal complexity also overcomes deconstructivist approaches that try to break down cases into individual variables that are independent of one another in terms of content and explain them in a way that is detached from their context. The case or the outcome is regarded and interpreted as a whole, as a holistic construct (cf. Meyer et al., 1993, p. 1178).

The number of complex, causal questions in research is high and, according to Braumoeller's constellation, goes back as far as Thomas Hobbes in the 17th century (cf. Braumoeller, 2003, pp. 212ff.). This complexity is still all too often met in everyday research with methods that methodically do not include it or ignore it completely (cf. Fainshmidt et al., 2020, p. 2, Misangyi et al., 2016, p. 258, Fiss, 2011, p. 411). For some time now, however, there have been efforts to overcome this discrepancy between theoretically understood complexity and methodologically practical, empirical research.

1.4 Neo-configurational thinking

Thinking in configurations, i.e. the interdependence of individual factors, which can only explain phenomena when they interact and cannot be decomposed and understood in a reductionist way, is in principle not a new approach. The understanding of the complexity of organizations and their internal interrelationships has been reflected in publications since the 1970s and 80s (cf. Fiss et al., 2013b, p. 2, Parente and Federo, 2019, p. 399). The principle

[...][that] the whole ist best understood from a system perspective and should be viewed as a constellation of interconnected elements (Fiss et al., 2013b, S. 2).

also goes back considerably further, to the work of Max Weber. His key work "Economy and Society"' from the early 20th century already deals with the holistic view on organizations (cf. Llanque, 2007, pp. 489ff.). The fact that their processes and internal systems are complex and interdependent (cf. Fiss, 2011, p. 393) is a fact that is also found in most business theories, whose characters are also inherently configurational (cf. Fainshmidt et al., 2020, p. 1). Thinking in configurations, however, inevitably generates a significantly higher complexity than, for example, unifinal explanatory approaches (cf. Fiss et al., 2013b, p. 5). In his work "Creating the corporate future", Ackoff summarizes this interplay of the factors involved in a very condensed and apt manner:

(1) The behavior of each element has an effect on the behavior of the whole. (2) The behavior of the elements and their effects on the whole are interdependent. The way each element behaves and the way it affects the whole depends on how at least one other element behaves. (3) However subgroups of the elements

are formed, each has an effect on the behavior of the whole and none has an independent effect on it (Ackoff, 1981, S. 15f.).

Essential is the fact that nothing can change in this mesh of elements without affecting the rest or the whole system. The effect is never responsible for a change in isolation, but always together with the others, which have been triggered. Such a complexity is at the same time opportunity and problem, strength and weakness (cf. Fiss et al., 2013a, p. 6). It enables a profound insight into the functional mechanisms of organizational reality. At the same time, it poses immense challenges for researchers, since organizations can no longer be treated like machines that generate a predictable reaction to an impulse (cf. Ackoff, 1999, p. 31). Such a way of thinking is of course clearly recognizably based on a system-theoretical tradition (cf. Misangyi et al., 2016, p. 257).

On a theoretical level, the understanding of such complex relationships was already available very early on. The core problem remained, however, that there were no methodological tools to handle this complexity in research projects (cf. Misangyi et al., 2016, p. 256, Fainshmidt et al., 2020, p. 2). However, existing methods such as cluster analysis, regressions, interaction analysis, etc. cannot adequately capture this complex causality (cf. Fiss et al., 2013b, p. 8, Fiss, 2007, p. 1184, Misangyi et al., 2016, p. 256, Fiss, 2011, p. 411). They often imply symmetrical, linear relationships between variable and outcome, which in reality do not or cannot exist in this reduced way. Simple correlations, always in the sense of a statement: "The more x we observe, the more outcome y we encounter" do not correspond to the existing circumstances. Organizations are rather a cluster of interdependent structures, than individual parts which are merely connected to each other and could be understood separately from each other (cf. Fiss, 2011, p. 1180,Fiss et al., 2013b, p. 6). Therefore, there must also be a move away from the question of factors that have the strongest, independent explanatory power (such as regressions do) to the question of how factors combine with each other to produce an outcome (cf. Misangyi et al., 2016, p. 261). For these are not in a "competitive struggle" with each other, but mutually condition, reinforce and combine each other (cf. Fiss, 2007, p. 1184).

Of course there have always been efforts to test configurational theories. But the tools used for this purpose mostly remained, according to Parente and Federo, in an "embryonic state" (Parente and Federo, 2019, p. 403; also: Misangyi et al., 2016, p. 256) of their development and never reached a maturity that they could be recognized as new methods. This lack of methods that could "keep pace" with empirical knowledge, in reverse, also inhibited the theoretical development (Fiss et al., 2013b, p. 2/7). Without tools that can capture and adequately map causal complexity, the generation of configurational theories was also considerably limited. Many of the existing problems regarding insufficient explanatory models in empirical organizational research can be attributed to this disconnectedness between theory and methodological equipment (cf. Fiss, 2007, p. 1181/1183,Misangyi et al., 2016, p. 258, Fainshmidt et al., 2020, p. 2).

This **first phase** of configurational thinking received new impulses with the publication of Meyer, Tsui and Hinings in 1993. They describe the "configurational theory" as opposed to the "contingency theory" (cf. Meyer et al., 1993, p. 1177). In it they summarize the already mentioned factors of wholeness, non-linearity, equifinality and interdependence in connection with factors of Kuhn's paradigm shift (cf. Kuhn, 1996). In other words, change as radical upheaval, rather than gradual change. For the first time the authors name the three central factors of causal complexity (cf. Meyer et al., 1993, p. 1178) and urge the scientific community to conduct organizational research under

these aspects (cf. Misangyi et al., 2016, p. 258). Herein lies the basis for a **second phase** of configurational research. However, there was still a lack of a suitable methodology. In order to investigate causal complexity, conceptual and methodological frameworks must be specifically adapted to this task (cf. Misangyi et al., 2016, p. 275).
Charles Ragin provided the first approaches to this in 1987. Causal complexity, so the claim, can thus be comprehensively grasped and mapped (cf. Fiss et al., 2013b, p. 3, Misangyi et al., 2016, p. 260, Fiss, 2007, p. 1194, Fiss, 2011, p. 412). His **Qualitative Comparative Analysis** (QCA) builds on the foundations of set theory in conjunction with configurational thinking. Both in themselves are not revolutionary starting points. Cluster analysis, for example, is also based on a configurational approach, just as fuzzy regressions follow a set-theoretical approach (cf. Fiss et al., 2013b, p. 3). Only the combination of both areas enables a novel method that meets the desired requirements. Therefore, it is necessary at this point to not only speak of a renaissance of configurational thinking. Instead Misangyi et al. coined the term **Neo-Configurative Perspective**. By means of it, it is possible for the first time to uncover configurational patterns, types and categories, as has long been demanded (cf. Meyer et al., 1993, p. 1179/1181).
Central elements of this new perspective are above all

- cases as set-theoretical configurations
- calibration of the partial quantity affiliation
- necessary and sufficient relations between the subsets
- counterfactual analysis of unobserved configurations (cf. Misangyi et al., 2016, pp. 260ff.)

These points are dealt with in detail in chapter 3.3.
The QCA can thus be seen as the central and so far only comprehensively recognized method of neo-configurational thinking and an explicit representative of complexity science, since it, according to Vaisey: "[...] begins with the null hypothesis of causal complexity and can be simplified only with positive evidence" (Vaisey, 2009, p. 310). Due to the focus on organizational factors in nursing homes, the QCA is particularly suited to answer questions of a configurational nature.

Chapter 2

Objective of the thesis

For the present work the following questions are to be worked on:

1. Are there applications of Qualitative Comparative Analysis in nursing science?

and

2. If so, how established and well-founded is the application in this field?

As this is a relatively new method, which is still increasing in its practical use, it will be investigated whether the advantages of coping with causal complexity, as mentioned by many authors, are actually used for nursing science. In addition, the methodological quality of such studies will be examined in order to draw a conclusion about its establishment.
A Qualitative Comparative Analysis will then be carried out as an example. The organizational variables from "PiBaWü" will be used to clarify whether the organizational structure of a nursing home itself has an impact on the outcomes of the residents. Expressed as a specific, configurative research question:

3. What sufficient or necessary conditions and/or configurations of organizational variables can be identified for nursing homes where residents have a high relative risk of falling?

Finally, the advantages and disadvantages of QCA in nursing science use will be examanied:

4. Which chances and problems result for the nursing science from the use of Qualitative Comparative Analysis?

Chapter 3
The Qualitative Comparative Analysis (QCA)

3.1 Introduction and history

The **Qualitative Comparative Analysis(QCA)** is a method developed by Charles C. Ragin, which he first introduced in 1987 in his work “The Comparative Method - Moving beyond qualitative and quantitative strategies" (Ragin, 1987). In the following years, this basis was further elaborated by the author himself and greatly expanded (Ragin, 2006, 2000, 2008).
Ragin initially concentrated on a clear elaboration of the differences between comparisons made in other social science methods and what he calls “Comparative Social Science":

> *While virtually all social scientific methods are comparative in this broad scene, in social science the term comparative method typically is used in a narrow sense to refer to a specific kind of comparison - the comparison of large macrosocial units (Ragin, 1987, S. 1).*

He thus places the focus of observation on the macroscopic level right from the start and consequently defines the objective of comparative social sciences as the explanation and interpretation of variations on this level (Ragin, 1987, S. 5). Ragin further presents the case-oriented, comparative method, i.e. a qualitative approach, and the variable-oriented, i.e. quantitative approach. He discusses the strengths and weaknesses of the approaches and points out that qualitative and quantitative approaches, in the sense of mixed method designs, are combined in research projects, but remain methodologically unconnected. In order to compensate for the respective weaknesses of the other side, the latter synthesizes his new approach with the help of Boolean algebra. At this point Ragin calls this approach **qualitative comparative method** (Ragin, 1987, S. 86). But he uses this term more in a way of description, than in actually naming his method. In particular, five claims are to be fulfilled:
1. Dealing with large number of cases This is intended to counteract the criticism of particularity, the neglect of the larger context.
2. Allowing complex, causal relations The problem of statistical procedures with linear addition of factors, which does not reflect the complex empirical reality, is to be avoided in this way.
3. Producing parsimonious explanations The method should, if desired, allow a theoretically founded data reduction. This would correspond to one of the central goals of the social sciences.
4. Allowing the investigation of cases as a whole and in parts At the same time, it should be possible to look at individual parts in isolation, as is the case with quantitative methods, as well as in context, as qualitative methods do.
5. Evaluation of competing explanations Different theories should not only be examined in one procedure and if necessary rejected, but their explanatory power should also be used as a basis for interpretations. Thus, several explanatory theories can stand side by side.
Ragin’s goal was to create a middle ground - a “via media” (Ragin, 1987, S. 84)- between complexity and generalization by combining the best features of the case- and variable-oriented approach. The method, initially developed as a formalization and extension of the comparative case study

(cf. Ragin, 2000; Delreux and Hesters, 2010), was limited at that time, due to a lack of technical solutions and a methodological development that had only just begun, exclusively to dichotomous, nominal-scaled values.

Beginning in the 2000's a wast theoretical development took place. Scientists further elaborated aspects of QCA an even expanded the approach to new terrain, resulting in special, distinct variants. Today the QCA community is a small but very active, open circle that is greatly connected through the internet, sharing new theoretical and practical knowledge.

3.2 Basic principles

Before the function of the method is described in more detail, the necessary basic principles and considerations on which the QCA is based are described. Qualitative comparative analysis is not a method which was "invented" from scratch, but is based on several mathematical fields and social scientific practices (cf. Schneider and Wagemann, 2012, S. 10). Five aspects play a central role in understanding the structure and approach of the method:

3.2.1 Comparison

Comparison is one of the most fundamental ways of gaining knowledge. In its most banal form it needs no scientific instruments and is part of human everyday life (cf. Rihoux and Ragin, 2009, S. XVII). The realization: "In June it is warmer than in December" is such an example. The knowledge generated in this way can then be directly translated into appropriate actions: A visit to a swimming pool is therefore better planned in June.

Comparisons are made at an ordinal level. A reference point, a comparative element, is needed from which to argue, similar to a zero point on a scale. If there is no knowledge about other characteristics of the entity to be compared, it can only be a description. The phenomenon can be described, but no reference, no relation, can be established. If, for example, the knowledge about the temperature in the remaining months of the year is missing, it cannot be said with certainty whether there is perhaps a more suitable time for a visit to a swimming pool than the present one. Such comparisons can be found everywhere in our daily lives and are a way of constructing our own self-image. Only the measuring of the opposite brings knowledge about one's own self. This "Theorie des sozialen Vergleichs[1]" was formulated in 1954 by Leon Festinger (Festinger, 1954). Thereby above all the frame of reference plays a decisive role. The annual income of a department head may be, from the point of view of a simple employee, a high one, but from the point of view of the head of the concern, at most, a medium. one. For in the land of the blind, the one-eyed man is king. The insight from a comparison is thus context-bound and depends on which comparative element is chosen.

In the scientific context, this everyday logic of comparison has been particularly appropriated and systematized as a comparative method. Alfred Brunswig defines, for example:

Zwei Objekte vergleichen heißt: sie aufmerksam nacheinander mit spezieller Hinsicht auf ihr gegenseitiges Verhältnis betrachten. Diese Intention auf die Erfassung des Verhältnisses durchwaltet den ganzen Prozeß[2] (Brunswig, 1910, S. 62).

[1] Theory of social comparison

[2] To compare two objects means to look at them attentively one after the other with special regard to their mutual relationship. This intention to grasp the relationship permeates the whole process

Here, as described above, he emphasizes the relations. What is needed first is a common attribute across all cases. The comparison then takes place on the basis of the shape of this characteristic (cf. Caramani, 2009, S. 29). Related to the above example, the annual income thus represents the common attribute: All employees in the company receive a salary. For a meaningful comparison then different characteristics within this attribute are necessary: In different, vocational positions different **amounts** of salary are paid. The comparison thus works with an interplay of equality and differentiation.
Objects for which no matching, comparative element is defined lack a common basis. If one wants to compare the rule of law of different countries, the exact definition of this construct is necessary. Different persons, instances or countries can have clearly diverging views on the freedoms and tasks linked to this principle. In relation to this factor, the cases must therefore be equivalent.
The opposite is true of the individual characteristics of the comparative element. Here it is essential that different values or forms exist. If all values of the attribute to be compared are identical, the cases are congruent. Only variance in the characteristic value creates differences for a comparison.

3.2.2 Set theory

Set theory is one of the most basic mathematical principles developed by the German mathematician Georg Cantor. In his publication in the "Mathematischen Annalen" the definition reads:

Unter einer ‚Menge‘ verstehen wir jede Zusammenfassung M von bestimmten wohlunterschiedenen Objecten m unserer Anschauung oder unseres Denkens (welche die ‚Elemente‘ von M genannt werden) zu einem Ganzen[3] (Cantor, 1895, S. 481).

In the years 1879 to 1884 he published a detailed description of set theory in six articles in the same journal (cf. Brückler, 2017, S. 145). The whole development took place over a time of nearly two decades, in the years 1873 to 1897. Again and again he was exposed to the hostility and skepticism of his colleagues during this time. Not least because from 1897 several paradoxes were discovered in the naive, non-axiomatic, set theory (cf. Brückler, 2017, S. 153)[4]. Due to the already large spreading of Cantor's idea one was forced to dissolve these contradictions instead of rejecting the approach again. The two mathematicians Ernst Zermelo and Abraham Fraenkel succeeded in doing this between the years 1908 and 1930 (cf. Brückler, 2017, S. 153f.). The latter extended the comprehensive axiomatization of Zermelos to the "Zermelo-Fraenkel set theory" (cf. Deiser, 2010, S. 267f.).
The framework of axiomatic set theory is so large that all mathematical objects (numbers, functions, etc.) can be represented in it. All areas of mathematics can thus be traced back to set theory (cf. Deiser, 2010, S. 11). At its core it deals with questions of order, size and infinity; thus it goes far beyond the dimenson of comparison, as mentioned in point 1.

Therefore, at this point we shall not devote ourselves to such an all-embracing doctrine in greater detail. Of particular importance for the introduction to the QCA, however, is the concept of sets as defined by Cantor. It gives the possibility to arrange all entities within the world into sets and

[3] By a 'set' we mean any combination M of certain well-differentiated objects in our view or thinking (which are called the 'elements' of M) into a whole

[4] For further details: Deiser, 2010, paragraph 1, chapter 13

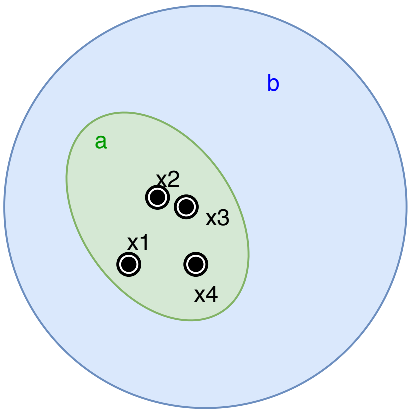


Figure 3.1: Example: subsets

subsets. The subset is a set a whose objects $m_1 - m_n$ are also objects of the set b (cf. Deiser, 2010, S. 25). Formally:

$$a \subset b \text{ if } x \in a \text{ and } x \in b \tag{3.1}$$

This requires one or more distinguishing criteria according to which all the parts can be sorted. For example, mankind (M) can be divided into the subsets $m_1 - m_6$: "Asians, Europeans, Australians, Africans, North Americans and South Americans". The differentiation criterion is the affiliation to a continent. The individual subsets $m_1, m_2, m_3, m_4, m_5, m_6$ form the set M. The respective objects $x_1, x_2, x_3, ..., x_n$ of the subsets are also objects of the superset M. This can be represented schematically as in figure 3.1. In relation to comparison similar elements are grouped with the aim of homogeneity **within** the set and heterogeneity **between** the sets. Decisive is the selected frame by means of which objects are grouped. Therefore, there are no "natural" sets, only "definitory" sets. Mankind M could be divided into the subsets men (m_1) - women (m_2), adults (m_1) - children (m_2), young (m_1) - old (m_2) etc. in the same way.
These examples sharpen once again the view for a necessary, selective delimitation of different concepts, as mentioned above: At what point is one considered to be "grown up"? Up to what age does one count as "young"? Are there finer nuances between the poles? These are questions that must be considered carefully before carrying out a QCA.
First, however, the possibility of representing and describing relations between sets and subsets should be presented.

3.2.3 Boolean algebra

The origin of this calculus lies with George Boole. In 1847 he published a first essay entitled "The Mathematical Analysis of Logic", in which he laid the foundations for the system, which was later supplemented and extended by other mathematicians and logicians. The author himself calls it "calculus of deductive reasoning" (Boole, 1847, subtitle). Contemporaries, however, thought much behind it to be incomprehensible and poorly conceived. Therefore, Boole's original approach was soon replaced by the "Boole-Jevons-Peirce-Schröder-Calculus" (cf. Hailperinodore, 1986, S. 135). As with set theory, it is not expedient to present the entire concept.

Ragin himself develops his Qualitative Comparative Analysis (Ragin, 1987, chapter 6) on this basis and used some selected aspects for it:
Boolean logic is essentially based on nominal data level and the use of 1 and 0. He introduces the "symbol" **1** as a universe. One under which all existing, conceivable objects can be subsumed, no matter if real or fictitious (cf. Boole, 1847, p. 15). The 1 is the central starting point and represents the existence, the positive (cf. Ragin, 1987, S. 86). Contrary to it the 0 stands for negation, absence, negative. If, for example, the occurrence of decubitus ulcers and fall events in residents of a ward of a nursing home is investigated over a certain period of time, a corresponding description of these events can look as follows:

Table 3.1: Incidents in a nursing home

resident	**fall**	**decubitus**
1	1	0
2	1	1
3	0	0
4	0	0
5	0	1

The event fall or decubitus exists for all those who have the value 1 in the corresponding column. These values can now be connected with each other using the operator **OR**. It is represented as "+" and corresponds essentially to the addition, but not in the arithmetic sense. According to Boolean logic the result is: 1+1=1. If the event in at least one of the cases is present at the conjunction of two values, the value of the solution is also positive, thus 1 (cf. Gregg, 1998, S. 30). Thus it is only decisive whether event A **OR** B occurs to affirm the entire term.
If fall events are referred to as A and decubitus ulcers as B, the following picture results when these are connected in the extended table:

Table 3.2: Incidents in a nursing home with OR opperator

resident	A	B	A+B
1	1	0	1
2	1	1	1
3	0	0	0
4	0	0	0
5	0	1	1

The new column therefore contains all cases in which at least one of the events A or B occurs.
As a further operator Boolean algebra offers the connection by means of **AND**, represented by the multiplication symbol "*". In mirror image to OR only those terms are considered true, where all considering partial aspects are true (cf. Gregg, 1998, S. 25). For the selected example this means:

Table 3.3: Incidents in a nursing home with OR and AND opperator

resident	A	B	A+B	A*B
1	1	0	1	0
2	1	1	1	1
3	0	0	0	0
4	0	0	0	0
5	0	1	1	0

In comparison to the OR connection there is now only a true statement for resident 2.
The events considered have so far been in their positive form. A value of 1 for event A thus means the presence of a decubitus. The Boolean system also allows the negation of events (**NOT**). This reversal is represented either by a tilde symbol (∼) or by the representation in lower case letters. If the variables A and B in the example are inverted, one gets ∼A and ∼B respectively a and b (read: "not-A" and "not-B"). For all values in the table this results in:

$$1 - x \tag{3.2}$$

Table 3.4 shows some exemplary operations with presend and absent conditions.

Table 3.4: Incidents in a nursing home with OR and AND opperator as well as negation

resident	A	B	a	b	A+B	a+b	A*B	a*b	A+b
1	1	0	0	1	1	1	0	0	1
2	1	1	0	0	1	0	1	0	1
3	0	0	1	1	0	1	0	1	1
4	0	0	1	1	0	1	0	1	1
5	0	1	1	0	1	1	0	0	0

The connection of values using Boolean operators is not only possible with values of 0 and 1, but also with decimal numbers. This will also be briefly explained here, since it is required when using fuzzy sets in the QCA. The meaning of this will be discussed at a later point in this paper (see section 3.3.3).
The previous table is slightly modified for this purpose:

Table 3.5: Decimal values with OR and AND opperator as well as negation

resident	A	B	a	b	A+B	a+b	A*B	a*b	A+b
1	0,7	0,3	0,3	0,7	0,7	0,7	0,3	0,3	0,7
2	0,9	0	0,1	1	0,9	1	0	0,1	1
3	0,4	0,7	0,6	0,3	0,7	0,6	0,4	0,3	0,4
4	0,7	0,5	0,3	0,5	0,7	0,5	0,5	0,3	0,7
5	0,6	0,7	0,4	0,3	0,7	0,4	0,6	0,3	0,6

When AND (*) is used, the smallest value over all corresponding cases is regarded as the result. This **minimum aggregation principle** (cf. Schneider and Wagemann, 2012, p. 45) is, at first glance, rather counterintuitive, but on closer inspection one can see the advantages over, for example, a mean value: Since the connection of two differently expressed information is of interest, the "weakest link in the chain" is used as an orientation. An average value would provide false information. If one interprets the values from table 3.5 as the degree of belonging to the respective set, as happens with the fuzzyset QCA, one can see that resident 2 suffered a severe fall (A = 0.9), but did not develop a decubitus (B = 0). In Boole's calculation, A*B = 0 results for this resident, whereas the mean value would be 0.45. If one looks for cases in which residents have suffered both events in severe form, the mean value suggests that both are at least moderately severe for resident 2. However, the fact that one of the events does not occur at all and thus does not belong to the intersection is lost. Using the minimum value thus leads to a qualitatively different interpretation of the values than using the average.
In the case of the connection using OR (+), however, the maximum value is considered across all events. Since in this case only one factor is necessary to fulfill the condition, the event with the highest value is selected here. If one considers cases in which residents have either suffered a severe fall **or** a severe decubitus, the following applies to resident 2: A+B = 0.9.

At this stage, the individual cases in the example serve as reference for the rows in the table. Each resident appears as a separate row, regardless of whether the information obtained is redundant or not. Thus the values of the events for residents 3 and 4 are exactly the same (A=0; B=0). Such duplications are avoided by using a **truth table**. Here, the possible combinations of characteristic (configurations) values serve as reference points for the table series. The following table can thus be generated for the selected example:

Table 3.6: Truth table: Incidents in a nursing home

#	A	B	a	b	A+B	a+b	A*B	a*b	A+b	cases
1	0	0	1	1	0	1	0	1	1	3, 4
2	0	1	1	0	1	1	0	0	0	5
3	1	0	0	1	1	1	0	0	1	1
4	1	1	0	0	1	0	1	0	1	2

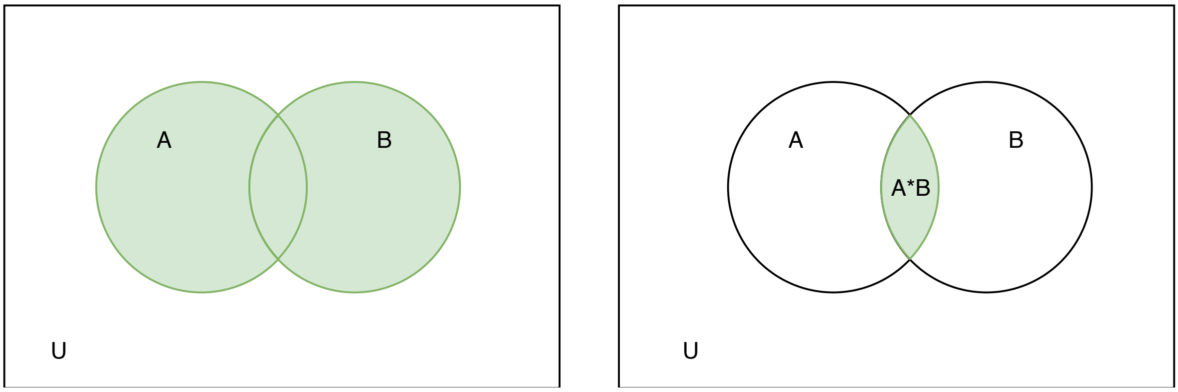


Figure 3.2: Venn diagrams OR and AND

In this case, the concrete cases or residents are listed in a separate column at the end. The focus of the analysis is no longer on the individual case, but on the characteristic values. Their influences on a selected outcome are at the centre of QCA's interest. This will be explained later.
The concentration on characteristic combinations also allows another form of representation by means of so-called **Venn diagrams**. Comparable to figure 3.1 the overlapping and coloring of areas shows the relationship of different sets.
The basis for this is a rectangle, which represents the totality U of the unit of investigation. Within this area partial sets are arranged according to their relationship. Related to the example, the total U, all residents of the nursing home at the time of the survey, contains two relevant sets: Set A of the residents who have fallen and set B of the residents who have developed pressure sores. If one now considers the cases in which at least one of the events is present, i.e. #2-4 in table 3.6, the Venn diagram looks like figure 3.2 on the left. Outside the green marked area there are the cases 3 and 4 from table row #1. Their characteristic value is "ab" and is therefore outside the considered sets.
On the right the Venn diagram shows all cases in which both characteristics exist together, i.e. resident 2 from table row #4. Besides the shown connection of sets, it is also possible to describe sets in their relation to each other.

3.2.4 Necessary and sufficient conditions

This relational consideration is done by the description as necessary or sufficient conditions and is a central element of the QCA.
For a condition (X) to be considered **sufficient**, it must be present in all cases in which the investigated outcome (Y) is present. If this is the case, the condition is a **subset** of the outcome. Thus, in the reverse, there must not be cases in which the condition is present, but the outcome does **not** occur.
Related to the previous example, our theory reads, for example: "Nursing homes in which residents suffer falls and decubitus ulcers have a low nursing quality. Decubital ulcers are a sufficient condition for low quality care.". If nursing homes now have a low nursing quality, then pressure sores must also occur among the residents there.
Cases in which an institution provides poor care, but no ulcers occur, are not relevant in this case. If

Table 3.7: Requirements sufficient conditions

		condition X absent	condition X present
outcome Y	present	allowed but not relevant	**allowed**
	absent	allowed but not relevant	not allowed

Table 3.8: Requirements neccesary conditions

		condition X absent	condition X present
outcome Y	present	not allowed	**allowed**
	absent	allowed but not relevant	allowed but not relevant

the outcome does not occur in the absence of the condition, this does not contradict the assessment of the condition as sufficient. Likewise, the quality of care is not decisive for assessing whether X is sufficient. The focus of consideration are cases in which the following applies: $X = 1$. It is therefore an asymmetric concept (cf. Ragin, 2008, p. 15, Schneider and Wagemann, 2012, p. 57). This also means that there may be other conditions besides X that exist when Y is present.
Schneider and Wagemann summarize these statements in the condensed table 3.7 (Schneider and Wagemann, 2007, p. 34).
If the requirements are met, the following formal expression is possible:

$$X \rightarrow Y \tag{3.3}$$

The representation by means of an arrow underlines the asymmetry once again. Only statements about X and Y can be made from the expression, but not about x and y.

It behaves mirror-inverted with **necessary conditions**: Here it is absolutely necessary that the outcome Y is always present if the condition X is fulfilled. There must be no cases, in which Y is given, but X is not fulfilled. Relevant here are all cases for which applies: $Y = 1$. For cases in which the outcome does not occur, the value of X is also irrelevant.
If one theory is: "Falls are a necessary condition for low nursing quality in homes", then for example fall events must be present compellingly for those residents, who live in an home, whose quality is classified as low. In these cases the outcome Y is a **superset** of the condition X, or formally expressed:

$$X \leftarrow Y \tag{3.4}$$

The four-field panel in table 3.8 shows the individual permitted and prohibited areas. Sufficient and necessary conditions can also be expressed via Venn diagrams:

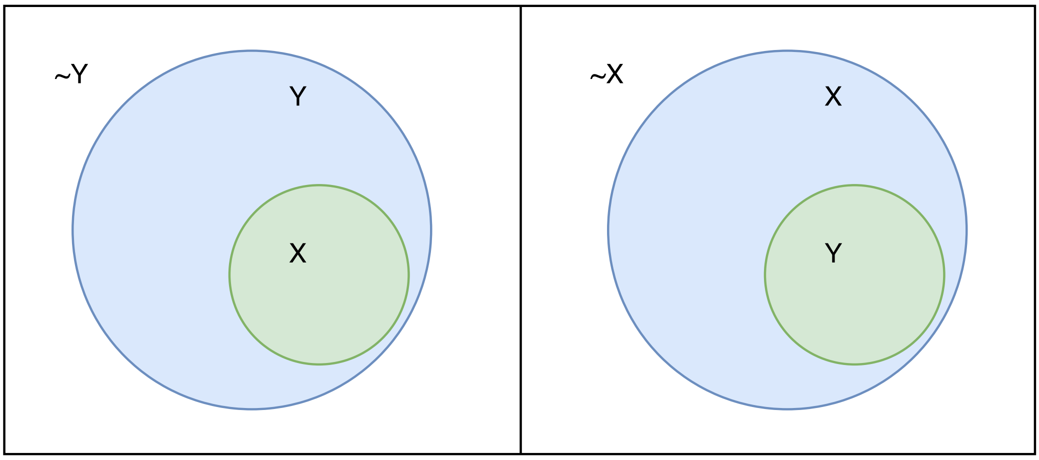


Figure 3.3: Venn diagram: Sufficient (left) and necessary (right) conditions

Here, once again, the relational character becomes pictorially visible. On the left side X is a subset of Y, what makes it a **sufficient** condition for the outcome Y; while on the right side X is superset of the outcome Y and therefore a **necessary** condition.

A special case of necessary and sufficient conditions are the so-called **INUS and SUIN conditions**. Due to its theoretical foundation on causal complexity and its three principles of conjunctural causality, equifinality and asymmetry, Qualitative Comparative Analysis is particularly well equipped to deal with and uncover these special combinations of conditions.
An INUS condition exists when the corresponding factor itself is not sufficient, but is a necessary part of a conjunction that is not necessary itself, but is sufficient for the production of the outcome (cf. Mahoney, 2008, p. 424, Mackie, 1965, p. 245). This somewhat unwieldy construct can best be explained by a theoretical solution path:

$$AB + cD \rightarrow Y$$

Condition A only has an influence on Outcome Y if B is also present; thus, considered in isolation, it is not sufficient in itsself but a necessary part to form a sufficient solution (AB). Whereas this is not necessary, but sufficient to explain the outcome, because cD is also a possible explanation.
As a counterpart, SUIN conditions describe a "sufficient, but unnecessary part of a factor that is insufficient, but necessary for the result". (Mahoney et al., 2007, p. 126).

$$(A + B)(c + D) \rightarrow Y$$

In this case, none of the conjunctions are sufficient in itself; but necessary to produce the outcome Y together with the other. Within the conjunction, the conditions are sufficient in themselves, but replaceable; therefore not necessary.
In the context of complex, empirical phenomena (see also section 1.3) it is necessary to be able to visualize such mechanisms of action on the outcome to be investigated. The QCA is a particularly suitable method for this.

3.2.5 Mill's methods

The comparison in the scientific sense has, beyond the pure description of the connections of conditions, also the claim to uncover causal connections (cf. Caramani, 2009, p. 2). This happens in the QCA and in many other case-oriented studies on the basis of Mill's methods (cf. Ragin, 1987, p. 35f., Schneider and Wagemann, 2007, p.73).
John Stuart Mill was one of the most influential British philosophers of the 19th century. He devoted his attention to virtually all important areas of philosophy and was also successful as an economist. As a figure of public life he influenced current events and embodied the type of "universal scholar" (cf. Capaldi, 2004, S. IXf.). His work “A System of logic” from 1843, in which methods of inductive proof are presented, is of importance for this paper.

Method of Agreement

The Method of Agreement states that for phenomena with the same outcome, which are identical in only one circumstance, this circumstance is the effect or the cause for the existence of the outcome (cf. Mill, 1843, p. 454). For clarification a truth table is to serve:

Table 3.9: Truth table: Method of Agreement

#	Conditions			Outcome
	A	B	C	Y
1	1	1	0	1
2	1	0	1	1

It can be seen that conditions B and C differ in both cases. Only condition A occurs in both cases. The outcome Y can therefore logically be explained by the presence of A. If Y corresponds to the outcome “low fall rate” and the conditions A to C correspond to different, quality-relevant events, e.g: A = annual training prophylaxis, B = internal quality commitee and C = regular resident information, then the annual training of the employees for fall prophylaxis would be the explanatory moment for rare falls with residents [5]. Ragin speaks of the search for “invariance”: The constant outcome Y is explained by other, constant conditions over all cases (cf. Ragin, 1987, p. 37). De Meur and Berg-Schlosser therefore also call the approach “most different systems with the same outcome' (MDSO)” (Meur and Berg-Schlosser, 1994, S. 198). Starting from the same outcome, such cases or “systems” are considered which differ to the maximum. For this distinction they use a **Boolean distance**. This is calculated from the sum of the variables, which have different values between two cases. In the case of the truth table 3.9, condition B ($\#1 = 1$, $\#2 = 0$) and A ($\#1 = 0$, $\#2 = 1$) have such a difference. The Boolean distance is therefore 2.
The method contains some uncertainties that Mill himself already recognizes. For even if cases are found that differ in all conditions, Mill writes:

> *We can seldom, indeed, be sure that this one point of aggreement is the only one [...] (Mill, 1843, S. 459).*

[5] At the same time A is a necessary condition for Y.

Since all possible explanatory approaches can never be examined or observed in a comparison, it cannot be ruled out that there may be other cases in which the (presumed) explanatory factor is present in a different form with the same outcome.
If, for example, another nursing home were to be found during a follow-up examination in which falls rarely occur but which does not carry out staff training, the conclusion drawn previously would be wrong (see table **??**).

Table 3.10: Truth table: Method of Agreement with additional case

#	Conditions			Outcome
	A	B	C	Y
1	1	1	0	1
2	1	0	1	1
3	0	0	0	1

Moreover, in the social sciences it is highly unlikely that empirical cases exist that are identical only in one condition. With regard to the example of nursing homes, there are limitations to the possible empirical diversity. These are due to internal and external influences on the organizational characteristic. This reduces the scope for action and increases the chances of greater agreement between the facilities (see section 1.2).
A further problem arises in those cases in which not only one condition, but two conditions apply to all cases. There is no way here to decide which of the two (or whether both) conditions is the causal factor.
Mill himself calls the Method of Agreement as a "inferior resource" (Mill, 1843, p.460), in cases where the application of the Method of Difference is not possible.

Method of Difference

Mill saw this method as clearly superior. It is based on the reverse principle of the Method of Aggreement. Thereby cases with different outcomes are considered, whose conditions are the same except for one (cf. Mill, 1843, p. 455). For this reason De Meur and Berg-Schlosser call this method "Most similar systems with different outcomes' (MSDO)" (Meur and Berg-Schlosser, 1994, S. 198).

Table 3.11: Truth table: Method of Difference

#	Conditions			Outcome
	A	B	C	Y
1	1	1	0	1
2	1	0	0	0

Looking at the modified truth table 3.11 of the above example, Mill concludes that the internal quality commitee (B) is decisive for the difference in the fall rates of the residents (Y). This is based on the logic that the same cannot contribute to differences (cf. Caramani, 2009, p. 48). The identically expressed factors A and C can thus be excluded from producing the different outcome. However, the problems of these two methods remain mostly the same. Despite often limited empirical diversity, it is unlikely to encounter cases that are sufficiently similar in all conditions and have a different outcome. Moreover, the social reality is too complex for only **one** causal factor to be identified for a phenomenon. The processing of multicausal phenomena does not work with these methods, which Mill explicitly mentions in a later edition of his "A System of Logic" in 1882 (cf. Mill, 1882, p. 611).

Joint Method of Aggreement and Difference

To control this problem, he combines the previous methods to the Combined Method of Agreement and Difference, which he defines as follows:

> *If two or more instances in which the phenomenon occurs have only one circumstance in common, while two or more instances in which it does not occur have nothing in common save the absence of that circumstance; the circumstance in which alone the two sets of instances differ, is the effect, or cause, or a necessary part of the cause, of the phenomenon (Mill, 1843, S. 463).*

Mill now connects the procedures from the previous methods.

Table 3.12: Truth table: Joint Method

#	Conditions			Outcome
	A	B	C	Y
1	1	1	1	1
2	1	0	1	1
3	1	0	0	0
4	1	1	0	0

If only rows 1 and 2 are considered, both A and C would be possible causal reasons for Y according to the Method of Agreement. By additionally considering rows 3 and 4, in which Y does not occur, C can be interpreted as the reason for the occurrence of the outcome. C is directly associated with the absence of Y.

Despite this improvement, there are still problems that limit the validity of the conclusions drawn. In all examples so far only truth tables with few rows were used, which cover only a part of the possible feature combinations. Starting from the three dichotomous variables, there are 9 different possibilities of the characteristic values [6]. Mill's methods do not provide an approach on how to deal with these unobserved table rows. Ultimately, any non-empirical combination has the potential to contradict the conclusions drawn.

Also in the case of plural causality, Mill's original approaches have no way of uncovering these elaborate structures (cf. Thiem, 2014a, p. 20). However, in 2018 Duşa introduced the concept of consistency cube (CCubes) (cf. Duşa, 2018), which is an extension of the joint method. Treating entities as “cubes”, that are to be “understood as a multi-dimensional matrix” (Duşa, 2018, S. 368),

[6] Formalized: The number of all possible combinations for k dichotomous characteristics is: k^2

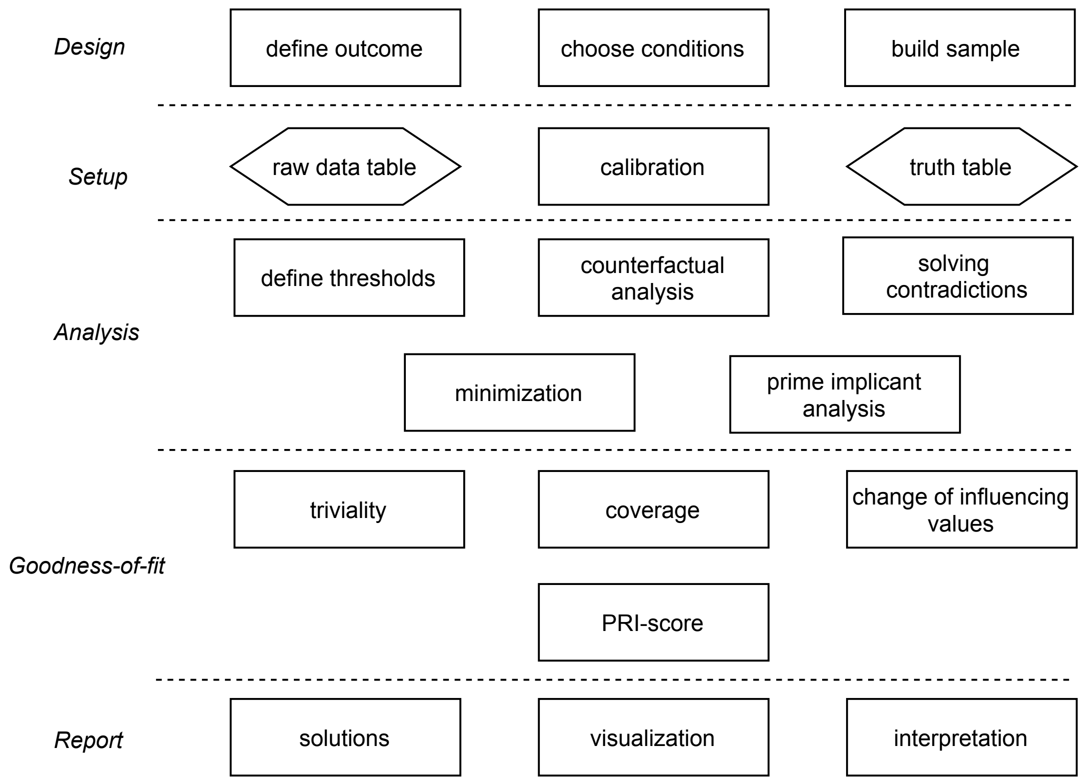


Figure 3.4: Schema: QCA process

one could subsume single conditions, configurations or even whole datasets under this term. Duşa uses them to develop a way for a much faster and efficient method of exact Boolean minimization. By partitioning the search for prime implicants by complexity levels (starting from a single condition) and terminating the search as early as justifiable, one can achieve a much faster and less memory consuming way to reach the most parsimonious solution, than with the existing non-polynominal attempts.

Qualitative Comparative Analysis offers precisely these possibilities for a formalized approach to uncovering causal factors to a phenomenon. However, the basic framework of its knowledge gain is essentially based on the methods of Mill. Schneider and Wagemann therefore also call them the "incomplete basic building blocks of QCA" (cf. Schneider and Wagemann, 2007, S. 76).

3.3 Execution of QCA

Based on these five basic components, a method was developed which has become increasingly sophisticated over the years. In this paper, the QCA is to be presented in terms of its individual steps. As will be shown in the following, it is by no means a linear procedure. Sub-steps can and should be repeated and adjusted after a review of the preliminary results. Schematically, the process can be represented as in figure 3.4.

3.3.1 The configurational model

The first step is to define the **outcomes**. A clear outcome must be defined in relation to the interest in knowledge and the research question. This is essential, since the theory-guided selection of the conditions and, if necessary, the compilation of the cases is linked to this (cf. Berg-Schlosser et al., 2009, p. 21). In contrast to classical, inferential-statistical procedures, in QCA one does not speak of independent variables, but of **conditions**. This is due to the theoretical foundation in neo-configurative methods, in whose understanding only the combination of factors triggers effects. A single, independent variable does not go far enough to explain complex phenomena (see chapter 1.3).

In the following, the chosen outcome must then be operationalised. This is done by selecting conditions which, in the opinion of the researcher, explain the occurrence or absence of the outcome. Here, the qualitative roots of the QCA already become clear: According to Schneider and Wagemann, these conditions do not "fall from the sky" (cf. Schneider and Wagemann, 2007, p. 44), but must be selected from a pool of possibilities. In order to avoid arbitrariness in the research process, this must therefore always be guided by theory (cf. Jordan et al., 2011, p. 1162, Berg-Schlosser and Meur, 2009, p. 25, Meur et al., 2009, p. 158, Ragin, 2000, p. 122). The researcher needs theoretically sound and substantial assumptions about why a chosen condition could be related to the outcome. In the best case there is a clear hypothesis in the form of a statement about sufficient or necessary connections (cf. Berg-Schlosser and Meur, 2009, p. 28). The creation of a configuration model therefore first of all requires comprehensive knowledge of the object under investigation.

Since the development of the method, authors have identified six strategies for the selection of conditions (cf. Jordan et al., 2011, p. 28). The first four are derived from a systematic consideration of QCA applications by Amenta and Poulsen (cf. Amenta and Poulsen, 1994). They supplemented these with a further possibility. Yamasaki and Rihoux later extended the list by another approach (cf. Yamasaki and Rihoux, 2009).

- comprehensive approach
- perspective approach
- significance approach
- second look approach
- conjunctural approach
- inductive approach

These approaches are usually not explained in the studies, but are chosen (intuitively), according to the conviction of the authors of the works.

The **comprehensive approach** takes into account all available theories of an outcome and the selection of conditions thus encompasses all available knowledge on the topic. The use of all theoretical considerations results in a multitude of possible causal factors. Amenta and Poulsen assume that in this approach all factors identified by the researcher are included in the QCA. On the one hand, this has the advantage that the chance of ignoring influential factors is minimized. On the other hand, however, they also recognize the problem of a large number of conditions: Thus, for example, "muddy results" (cf. Amenta and Poulsen, 1994, p. 26) that are difficult to interpret and unsuitable for theory formation can arise. Yamasaki and Rihoux as well as Jordan et al. therefore emphasize the necessity of reducing the results of such a search for conditional factors in an iterative selection process (cf. Yamasaki and Rihoux, 2009, p. 126, Jordan et al., 2011, p. 1163).

In the **perspective approach** this reduction takes place in advance. Here, only individual factors are selected from the available theories and incorporated into the QCA. This ensures a reduced number of conditions with a strong theoretical basis (cf. Amenta and Poulsen, 1994, p. 26f.). However, such a limitation can mean that decisive conditions are not included in the analysis, since they were not relevant in the eyes of the researcher, but would be essential for the explanation of an outcome.

The **significance approach** can be a remedy to not prematurely exclude such explanatory factors. This approach uses significance tests from classical inferential statistics for the selection of conditions. However, it should not be overlooked that this disregards the principles of configurational thinking and again refers to the additive relevance of individual factors. Factors which only develop their influence on the outcome in interaction with others are not identified with this approach. Therefor, it reproduces the problems of the classical, statistical approaches (vlg. Amenta and Poulsen, 1994, p. 28). Even though the author did not come across a study where this approach was used, it should be emphasized that QCA users should refrain from employing it.

The **second look approach** ultimately simply corresponds to an iterative approach to QCA, in which other or new variables are built into the investigation in case of an insufficient result of the analysis. The researcher thus identifies at second glance possibly better suited conditions (cf. Amenta and Poulsen, 1994, p. 29). Amenta and Poulsen themselves note here that this approach, if the selection of further factors is not bound to strong theoretical assumptions, merges seamlessly into the "perspective approach". Since the entire analytical process is itterative, this differentiation appears redundant.

Amenta and Poulsen see their own approach, the **conjunctural approach**, as being most compatible with the methodology of Qualitative Comparative Analysis. In this approach, the conditions are selected on the basis of theories which in turn consider the outcome in a multi-causal way (cf. Amenta and Poulsen, 1994, p. 29). Here, too, the question remains whether this is really a differentiable selection procedure. The selection takes place selectively, on the basis of certain (in this case multi-causal) approaches and is thus also a form of the perspective approach.

In Rihoux and Ragin's 2009 anthology "Configurational Comparative Methods", Yamasaki and Rihoux supplement the **inductive approach**: Inductively, from the consideration of the cases, conditions are developed which can be significant for the outcome (cf. Yamasaki and Rihoux, 2009, p. 129). This approach has an exploratory character and is particularly suitable when theories are rare. Jordan et al. take up this view when they argue that QCA can also be used as a theory-building procedure. Conditions can then be chosen on a loose, theoretical basis and for inductive reasons and thus a new theory can be developed (cf. Jordan et al., 2011, p. 1162). Qualitative Comparative Analysis then serves to test this construct.

This first step of the method already creates a hurdle for nursing. After a peak phase in the 1980s and 1990s, the development of theory seems to have come to a standstill in large parts (cf. Moers et al., 2011, p. 351). Following a strong reception by the major nursing theorists in the USA, who wanted to theoretically underpin the entire nursing process with their approaches, the focus is now mainly on practice-oriented, empirical work (cf. ibid.). Such a lack of theories makes the classic approaches to the selection of conditions considerably more difficult. While the political science, from which the QCA emerged, obviously has a rich fund of theoretical considerations for its field, the same applies to nursing only to a much more limited extent. Therefore, however, the "inductive approach" in particular can provide a beneficial to how nursing can deal with this method.

Including significance values for selection seems attractive from a quantitative point of view in order to identify important factors in advance, but it should be rejected at this point because it is contrary to the methodological basis.
The “comprehensive approach”, on the other hand, contrasts with very clear, more recent research findings. Starting from the consideration that when applying the method to randomly generated, non-empirical data, contradictions inevitably arise in the rows of the truth table (see section 3.3.5) and that the consistency values are low (see section 3.3.6), Marx and Duşa, on the basis of the simulation of more than 5 million data sets, find that this is only true up to a certain ratio of conditions to cases (Marx and Duşa, 2011). If in a crisp-set QCA too many conditions are included in the analysis of a small number of cases, there is the possibility of randomly consistent and unambiguous solutions (cf. Marx and Duşa, 2011, p. 111ff.). With this finding, earlier recommendations on the case-condition ratio, as given by Berg-Schlosser and de Meur (4-7 conditions in 10-40 cases (cf. Berg-Schlosser and Meur, 2009, p. 29)) become obsolete.
However, a reduction of the conditions is also necessary for other reasons. By considering all possible configurations, i.e. logically possible connections of the conditions with each other, in the truth table (see chapter 3.3.4), the number of possible combinations increases exponentially. Each condition spans an additional dimension in the logical space. This “property space” or “feature space” goes back to Paul Lazarsfeld’s typological considerations from 1937. He describes the possibility of specifying variables on a cross-axis, similar to the reference system in analytical geometry (cf. Lazarsfeld, 1937, p. 126.). Thus, each k condition in a QCA also receives its own axis in a K-dimensional space. The total number of dimensions is 2^k. With the recommended seven conditions by Berg-Schlosser and de Meur, this already means 128 configurations. To find empirical cases for each of them within the data becomes more unlikely with each condition (cf. Ragin, 2000, p. 78f.) or is impossible with medium case numbers. From these unoccupied dimensions or configurations (“logical remainders”) further methodological problems arise, which are dealt with in section 3.3.5.
A final reason for a rather small number of conditions is the fact that for a larger number it can happen that each case receives its own solution path, i.e. there is no approach for a generalizability of the results or explanatory patterns can be found. Thus, the result would remain purely descriptive at the case level. If, in addition, too many conditions are integrated into a solution path, a result emerges which is difficult to interpret in terms of content (cf. Greckhamer et al., 2013, p. 60, Greckhamer et al., 2018, p.6).

Ultimately, the decisive factor for the selection of conditions is above all that they vary across the cases (Berg-Schlosser and Meur, 2009, p. 28), since without variation no comparison is possible (cf. Caramani, 2009, p. 31). This step of the construction of a configuration model is only little controllable or possible to standardize and clearly a **qualitative element** of the method. Above all, it depends on the interest of the investigator and must be theoretically justifiable (cf. Ragin, 2000, p. 122). Therefore, transparency is required in the choice of conditions (cf. Meur et al., 2009, p. 158). In the end, the results of the QCA depend to a large extent on whether the person carrying out the analysis has succeeded in including the decisive conditions in the analysis. Due to the restriction in the number depending on the size of the sample, this decision plays an even greater role in smaller studies.

3.3.2 Sample and case selection

Qualitative comparative analysis also differs in the selection of cases to be included in the analysis. In variable-oriented, classical statistical approaches, populations are often regarded as empirically given (cf. Ragin, 2000, p. 46). If, for example, the effects of national prevention programmes on the health of the entire population are investigated, all inhabitants of the country form the population from which, in turn, samples are taken for analysis. The population is clearly defined and delimited. The individual cases are considered comparable and interchangeable. Ragin criticizes three aspects of this approach from the perspective of comparative methods:
By the unreflected adoption of apparently obvious populations **heterogeneity can be hidden** and seen as an error of a statistical analysis. However, deviating cases or outliers may just as well be an indicator that the population is too heterogeneous to be considered as a single entity. At the same time, however, since populations are seen as immutable through the process of analysis, this **inflexibility** prevents the recognition of diversity. Closely related to this is also the aspect of **causal homogeneity**: The assumption that conditional factors act in the same way across all cases. If one assumes, that all cases invariably belong to an empirically given population on which causal factors must all have the same effect in the same way, qualitative differences, which should actually lead to a division of the population, are merely regarded as measuring errors in a probabilistic system (cf. Ragin, 2000, p.55ff.). In the classical form of QCA, therefore, great attention is paid to the composition of the sample. Above all, it is important to define exactly what is meant by a single "case" and where the boundaries of a population lie.
All cases require a sufficiently homogeneous basis. They must share enough properties so that they can be considered instances of a common population and thus be "equal" enough to serve as a starting point for comparison (cf. Kahwati and Kane, 2019, p. 48). For these approaches a high degree of familiarity with the individual cases is therefore necessary, as it is especially crucial in (individual) case studies (cf. Lamnek, 2010, p. 274). This proximity of the investigator to the cases is intended to prevent heterogeneity in the sample from remaining undetected. Once again, the origin of QCA from the case-oriented, qualitative methods becomes clear. At the same time, however, the cases must also exhibit sufficient heterogeneity so that they cannot be considered exactly the same. If this were the case, it could only be determined whether or not a certain combination of characteristics leads to a certain level of outcome. However, since the aim of the QCA is to reveal the influence of different configurations on the outcome, both the values of the conditions and of the outcome must vary across the selected cases. Therefore, Ragin also speaks of the field of tension between sameness and differences (cf. Ragin, 2000, p. 45). In Qualitative Comparative Analysis, populations are therefore considered an open construct. Cases can be selected **iteratively** during the analysis process and individual instances can be added or excluded depending on the situation. Berg-Schlosser and de Meur recommend maximum heterogeneity over a minimum number of cases (cf. Berg-Schlosser and Meur, 2009, p. 21).
It becomes clear that the selection process of cases, conditions and outcome often goes hand in hand, due to the demands on them. At the end of the process, a sample is created, which has been compiled with regard to the outcome of each case and the underlying conditions. It reflects the diversity of the characteristics examined by the user and at the same time minimizes the heterogeneity sufficiently to be comparable. Cases are regarded as "complex configurations of events and structures" (Ragin, 2000, S. 57), which are purposefully included in the analysis, considered

in their entirety and should not only be understood as homogeneous, exchangeable characteristic carriers from a set of further, uniform characteristic carriers. The aim is to select cases on the basis of theoretical criteria that are related to the research question (cf. Thomann and Maggetti, 2017, p. 6). This extremely clear and hard distinction from "conventional" forms of case selection and sampling can be explained by the attempt to install the comparative method as a new methodology capable of overcoming old problems. Increasingly, however, an opening is taking place which, in addition to the strict, qualitatively-theoretically based case selection, also allows for more pragmatic reasons and thus allows an application for higher case numbers. Since, technically speaking, there is no limit to the number of cases for a QCA and even the computing capacity of a simple home PC is sufficient to process several thousand cases, since around 2013 there have been more and more attempts to apply the method for large samples and to embed this procedure in a methodological framework. So-called **Large-N QCA** approaches necessarily turn away from some underlying principles of classical QCA (cf. Greckhamer et al., 2013, p. 50, Emmenegger et al., 2014, p. 4). The original approach limits the number of cases to the extent that the investigator must have a close familiarity with each case. To be included in the analysis, knowledge of the outcome and the chosen conditions must be available, as well as knowledge of the general composition of the case as a whole. This may still be possible for small and medium case numbers, but in-depth case knowledge with more than 50 cases is hardly possible.

With regard to case selection, it would be obvious to draw a random sample from the data, but this is often explicitly discouraged (cf. Greckhamer et al., 2013, p. 58). There are two main reasons for this: The assumption of generalizability for random samples is primarily based on characteristics of central tendency, variability and the distribution form of the data (cf. Greckhamer et al., 2013, p. 59) and can only apply if the sample is assumed to be representative. To what extent this is given, however, can only be determined with certainty in very few cases. Even more decisive for the method is the assumption that random sampling could limit the diversity of cases. Configurations that occur only rarely in the population can be ignored by the random selection and their explanatory power for the outcome can thus be ignored. However, it is precisely such cases that could provide particularly strong explanations for the phenomenon under study. To avoid such problems, either all theoretically relevant cases can be included, or a stratified sample can be drawn which reflects the diversity of the overall sample (cf. Greckhamer et al., 2013, p. 58). However, this also causes problems. Often it is not possible to collect data on all cases of interest or to obtain data from other sources. Often it is not even possible to determine how large the potential population is. If the influences of different forms of prevention on smokers in a federal state are examined, it is unclear how many smokers actually live there. For stratification, in turn, extensive knowledge of the nature of the population is necessary in order to achieve a meaningful demarcation of the individual strata.

After the first sub-step "Design" (see figure 3.4), it can be summarized that only a few methodically controlled and comparable procedures are possible when creating the configuration model. The decisions on the conditions used and the number of cases examined are based on the user's theoretical knowledge and his preliminary considerations regarding possible interrelationships. Qualitative Comparative Analysis in this respect is strongly based on non-standardized procedures and, due to this openness, offers the possibility to model sample and conditions in detail. However, transparency with regard to the selection criteria is crucial in order to prevent arbitrariness. In general, these first steps of a QCA are treated only very casually in the literature.

3.3.3 Calibration

In the calibration process the raw data of the conditions and the outcome are converted into set-membership values (SMV). This step determines to what extent the conditions of the cases belong to the respective subset. Since the QCA is based on Boolean algebra, this transformation into TRUE/FALSE values or 0, complete non-membership to the subset, and 1, complete membership to the subset, is necessary. The goal is to show the qualitative differences. A calibration must be clearly distinguished from a measurement.

To clarify this difference the example of water temperatures is often used: -10°C and 10°C cold water has a measurable difference of 20°C. The same applies to water with a temperature of 20°C and 40°C. From a pure measurement point of view, these distances do not differ. However, there is a **qualitative** difference between the -10°C and 10°C cold water, because it is once in liquid and once in solid state. This transition of the states of aggregation happens at 0°C and changes, so to speak, the affiliation of the water to the subset "ice". As a calibration threshold value, therefore, exactly this temperature would have to be chosen at which the qualitative state changes.

The same applies to the QCA when calibrating conditions and outcomes. These are represented by subsets. Empirical cases must be evaluated according to their affiliation to these subsets. For this purpose, the boundaries of a set must be delimited by membership criteria, i.e. the question "What belongs to a set and what does not?" (cf. Kahwati and Kane, 2019, p. 69). This qualitative difference is defined by a **threshold**, which marks the transition between belonging and not belonging and "that seperate[s] particular groups of data from each other in the calibration process" (Thiem and Duşa, 2013c, p. 29). Within the QCA, this is referred to as the **qualitative anchor** and is specified with the SMV of 0.5. It is thus located exactly in the middle between complete affiliation (1) and non-affiliation (0) and can also be found in the literature as a "point of maximum ambiguity" or "crossover/breaking point". Cases in which a condition has an SMV of 0.5 are neither in nor outside of a set, i.e. they cannot be assigned qualitatively. Therefore, the assignment of such a value must be avoided in the calibration.

The qualitative anchor is the most substantial point within a calibration process (cf. Schneider and Wagemann, 2012, p. 287) and at the same time in many cases a point of great conceptual difficulty, since its choice is by no means always as clear as in the ice example. The question when something changes its qualitative nature is at the same time the question when a variance is relevant and when it is irrelevant (cf. Ragin, 2008, p. 83). For clarification, the Sorites-paradox shall be taken up: A grain of sand on the ground does not make a pile of sand. Even if you add another one, it does not. Even five, ten or a hundred do not change anything about it. But if more and more grains are added, at some point the moment is reached where one can speak of a heap. To define which grain made this decisive difference between an accumulation of individual grains and a heap of sand is not clearly possible. And even if a grain of sand is then removed from this heap, one would still speak of a heap. It is similar, for example, with social constructs such as poverty and wealth. In Germany one is currently considered to be "poor" as single person with a monthly netto wage of less than 781€[7]. The 60% value of the average netto monthly wage was used as the calibration

[7] `https://de.statista.com/statistik/daten/studie/510/umfrage/einstufung-in-arm-und-reich-fuer-singles-und-paare/`

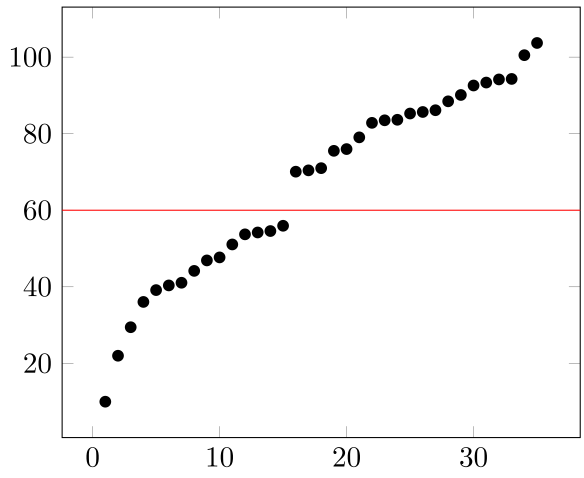


Figure 3.5: Sample plot calibration

value. However, this can also be lowered or raised by several percentage points or euros without there being an immediate qualitative change.

This illustrates how open ultimately the question of a calibration threshold is and how necessary the inclusion of external knowledge and expertise about the element to be calibrated is (cf. Kahwati and Kane, 2019, p.70, Ragin, 2008, p. 86f.). For a meaningful calibration in a Qualitative Comparative Analysis, sample-independent, empirical findings or theories must be included to determine the qualitative difference. If this is not done, systematic bias may occur. For example, if the median of the population of a cardiological ward is chosen for the calibration of blood pressure values, this median may be significantly higher than that of the rest of the population. A meaningful threshold value for the set "normal blood pressure" could therefore only be selected by resorting to the usual conventions outside the data. It is crucial that the same external criteria and data are used across all cases when calibrating a condition (Kahwati and Kane, 2019, p. 68).

Although sample-based calibration should be avoided whenever possible (cf. Greckhamer et al., 2018, p. 8), it is possible that for some conditions within a configuration model there are no theories or empirical knowledge on the basis of which SMVs can be assigned. In such cases, thresholds must be selected from the data itsself, taking into account the distortions that may occur. For this purpose it is possible, apart from position parameters, to plot the data as a diagram in order to visualize the breaks that occur in it, which can serve as orientation for the calibration. Figure 3.5 shows the distribution of hypothetical data for a condition. It can be seen that there is a gap approximately at the value of "60". This value can be used to constitute two qualitatively different groups.

Another method in the absence of external calibration factors can be a hierarchical cluster analysis. For this purpose, the R-package "QCA" offers a "find threshold" function based on this method (cf. Duşa, 2020, pp. 35f.).

When working with Qualitative Comparative Analysis, one can basically distinguishes **two** procedures that play a role from the time of calibration. Either the initial values are dichotomously converted into membership-values of 0 or 1, or into continuous values between 0 and 1. In the first case you speak of **crisp-set QCA (csQCA)**, in the second case of **fuzzy-set QCA (fsQCA)**. Crisp-sets are the original approach developed by Ragin; the principle of fuzzy-sets was integrated

Table 3.13: Sample data: Calibration

#	Number of beds
1	130
2	91
3	36
4	59
5	21
6	48
7	26

Table 3.14: SMVs depending on reference

#	Number of beds	SMV depending on reference		
		Median	Arith. mean	External
1	132	1	1	1
2	91	1	1	1
3	36	0	0	0
4	57	1	0	0
5	21	1	1	1
6	48	/	1	0
7	26	0	0	0

into the QCA much later.

Crisp-set calibration

"[...]crisp sets are just fuzzy sets with no membership values on the interior of the unit interval [...]" (Smithson and Verkuilen, 2006, S. 11). Therefore csQCA is strictly speaking only a special form of fsQCA. In many parts of the literature both approaches are clearly separated and treated as two separate forms. In the opinion of the author this separation can be traced back to the historical development of the method and is no longer up to date. The most recent methodological publication (Kahwati and Kane, 2019) dissolves this separation, too.

Calibration in crisp values splits the expressions of a condition into two possibilities: Belonging to the set (SMV = 1) and not belonging to the set (SMV = 0). The main difference is between relevant and irrelevant factors. The decisive factor is, as described above, the sensible choice of the crossover point.

Table 3.13 shows seven nursing homes and the number of beds they offer. The affiliation to the set “large facility” is to be calibrated. If there was no external knowledge about the number of beds in German nursing homes, the median (48) or the arithmetic mean (58) could be chosen as a threshold value. Then the corresponding SMV is assigned to each case. For values above 48 or 58 “1”, below “0”. Table 3.14 clarifies that the calibration of the values must never be done only mechanically. The raw value of case #6 is exactly on the threshold value of 48 when choosing the median in the example. This means that it cannot be determined whether the number of beds is inside or outside the set “large facility”. For case #4 it is also shown that the changed crossover point has led to

different, qualitative interpretations. When calibrating using the arithmetic mean, the case loses its membership of the set compared to the use of the median.
Since the nursing care statistics of the Federal Statistical Office provide empirical findings on the size of homes in Germany, it would be appropriate in this example to rely on this source. According to the report, the average number of resident beds across all providers is 64 (cf. Destatis, 2018, p. 21). Using this value to define above-average-sized facilities, it is shown that the cases #4, #5 and #6 became non-members of the subset as soon as the sample-external criteria were applied. In this example, the use of internal criteria leads to a clear underestimation of what a **large** facility is.

fuzzy-set calibration

The use of crisp sets requires a strong conceptual separation between two poles of one criterion. Very few social concepts, however, can be so clearly divided into just two categories (cf. Smithson and Verkuilen, 2006, p. 6). Such dichotomization often shortens them too much to have a really profound meaning. The question about the religiousness of a person cannot be divided into "yes" and "no" without making the subset of religious people extremely heterogeneous. Which criteria defines "religious"? The formal membership in a church? The weekly attendance of the church service? The donation for charitable purposes? The voluntary work in the parish? Or several factors together? And if so, to what extent? Is one attendance at the service per month and one donation per year sufficient to be "religious"? Often, concepts are too abstract to be classified into precisely defined categories (cf. Verkuilen, 2005, p. 51); much more the boundaries are fluid and the forms of expression blurred.
To make this problem comprehensible for the QCA, Ragin introduced the concept of fuzzy sets with his work "Fuzzy-set social science" (Ragin, 2000). The idea behind it comes from the field of electrical engineering and forms a basis for the programming of neuronal networks and artificial intelligence. It was developed in 1965 by the Azerbaijani mathematician and computer scientist Lofti A. Zadeh (Zadeh, 1965).
Unlike mathematical objects, empirical or social objects can only very rarely be precisely defined, as the example of religiousness shows (cf. Smithson and Verkuilen, 2006, p. 6, Schneider and Wagemann, 2012, p. 27). There always remains a certain fuzziness to the concept (Adcock and Collier, 2001, p. 532f.). Zadeh therefore opened the beforehand rigid system of set membership and defined it as:

A fuzzy set is a class of objects with a continuum of grades of membership. Such a set is charaterized by a membership [...] function which assigns to each object a grade membership ranging between zero and one (Zadeh, 1965, S. 338).

The membership function is defined as

$$f_A(x) : X \rightarrow [0,1] \tag{3.5}$$

where an object x from the set of objects X is assigned a value on the unit interval [0,1] depending on the degree of affiliation to the set A (cf. Zadeh, 1965, S. 339).
Fuzzy sets, in contrast to crisp sets, thus contain not only a qualitative differentiation ("difference in kind"), but also an additional quantitative differentiation ("difference in degree"). "Religious" can thus be divided into the two basic forms "religious" and "non-religious", but can also include the

Table 3.15: fuzzy SMVs with verbal correspondence

Expression	Fuzzy value
not religious	0
mostly not religious	0.25
mostly religious	0.75
religious	1

linguistic concept of the differences in degree between the two poles. Graduated linguistic qualifiers such as "not at all", "rather not", a little", "clearly", "very" etc. are transformed into continuous set membership values. Ragin describes this property as **dual diversity** (cf. Ragin, 2000, p. 151). Fuzzy sets can therefore be regarded as simultaneously qualitative and quantitative (cf. Ragin, 2000, p. 154, Ragin, 2008, p. 82, Masue et al., 2013, p. 217, Schneider and Wagemann, 2012, p. 27).
An example of how fuzzy values can be verbalised respectively how linguistic lables can be expressed in terms of fuzzy values is shown in table 3.15. Cases with an SMV of 0.25 thus belong qualitatively speaking to the non-members in the set "religious" (A), since the breaking point of 0.5 was not exceeded. Nevertheless, their membership is greater than in such cases with an SMV of 0. Apart from cases of complete membership or non-membership, cases in fuzzy sets always have a partial membership in the respective set **and** in its negation (cf. Schneider and Wagemann, 2012, p. 28, Kahwati and Kane, 2019, p. 74). The corresponding cases thus have an additional membership in the set "non-religious" (a or ∼A) of 0.75. By means of this fuzziness the complexity and problems of the definitional sharpness of concepts found in empirical research can be systematically grasped and made manageable (cf. Smithson and Verkuilen, 2006, p. 1). A set is fuzzy/fuzzier the more values lie on the continuum instead of lying on the two endpoints 0 and 1. Through this firmly defined and qualitatively significant minimum **and** maximum, Ragin argues that fuzzy-set membership scales have a higher data level than usual ratio scales, where only the zero point is fixed (cf. Ragin, 2000, p. 155).
There are two basic procedures for the actual conversion of the initial values into membership scores: Direct assignment (or "qualitative calibration") and transformative assignement (cf. Duşa, 2020, p. 93, Verkuilen, 2005, p. 465). This transformative calibration is further divided into a direct and an indirect method by Ragin (cf. Ragin, 2008, p. 85ff.).

direct assignment

In the case of direct or qualitative calibration, the fuzzy membership scores are not assigned by a mathematical transformation, but "by hand" by the investigator. As with all calibration methods, "substantive and theoretical knowledge" (Ragin, 2009, p. 92) play a decisive role in the choice of SMVs. Based on the knowledge about the circumstances of the condition to be calibrated, the number of gradations and the respective fuzzy value is determined. Also, the intervals between the steps do not necessarily have to be proportional to each other (cf. Ragin, 2009, p. 91). The only decisive factor is that the stages can be differentiated from each other in terms of content and quality (cf. Kahwati and Kane, 2019, p. 74). Table 3.16 extends table 3.15 by a column in which the scores of a fictitious questionnaire on religiosity are assigned to the SMVs. As described at the beginning of this section, it is the task of the researcher to distinguish relevant variance from irrelevant variance.

Table 3.16: Sample calibration “religiousness”

Expression	Score	Fuzzy value
not religious	0-4	0
mostly not religious	5-9	0.25
(qualitative anchor)	10	0.5
mostly religious	11-16	0.75
religious	17-20	1

For example, it would not make a qualitative difference whether subjects receive 0, 1, 2, 3 or 4 points in the questionnaire. All cases would be assigned the same membership score of 0. This must be based on a theory of the extent to which the scores represent the concept of “religiosity” and the extent to which there are different degrees of variation that are reflected in the five possible fuzzy membership scores.

There are several problems with this procedure. For one, the process of forming qualitatively similar groups, distinguishing them from qualitatively different groups and assigning them a fuzzy value that represents their position on a continuum is a major challenge, especially in the case of concepts that are difficult to grasp, such as competence levels (cf. Verkuilen, 2005, p. 471). Even with a detailed theory, the procedure places high demands on case knowledge and knowledge of the condition to be calibrated. Due to this high influence of the researcher, direct calibration is particularly bias-prone. Above all, the problem of an endpoint bias (cf. Thohle et al. 1979, quoted in Verkuilen, 2005, p. 472), i.e. the shift away from the centre of the membership value continuum to its endpoints, plays a role here.

The calibration form, which at first glance appears simple, therefore poses a number of methodological challenges.

Due to the rather limited choice of continuous fuzzy values (five- or seven-level scales are often used in accordance with Liekert scales) with direct assignment, Kahwati and Kane also speak of “fixed value fuzzy sets” (Kahwati and Kane, 2019, p. 73).

Transformative calibration

In contrast, transformative calibration procedures use the full bandwidth of the unit interval. Again, external knowledge and theoretical considerations of the user play a decisive role. Structuring by means of sample-external knowledge results in a “theoretically motivated transformation"’(Verkuilen, 2005, p. 479).

Next, the **indirect method** will be described. It is basically based on the direct assignment described above. Here, too, the raw values are divided into qualitatively different and content-rich groups and provided with a fuzzy membership score, which represents a relative order of the cases (cf. Kahwati and Kane, 2019, p. 75, Ragin, 2008, p. 94ff.). In a second step, these values are then applied to the initial data using fractional polynomial regression to obtain refined SMVs. The mathematical process of the transformation is thus underpinned by the theoretically and/or empirically based considerations of the investigator on sameness and difference of cases. However, due to the logarithmization of the values that occurs during the regression, there must not be any values of 0 in the output data, since the logarithm is not defined for this purpose. Alternatively, a very small

Table 3.17: Sample indirect calibration

#	Score	Fuzzy value	Calibrated
1	16	0,75	0,86
2	6	0.25	0,26
3	4	0.00	0,03
4	19	1	0,98
5	12	0.75	0,66

value of 0.001 may be selected.

As shown in table 3.17, the resulting values are much finer in their gradation. Case #1 and #5 have a score difference of four points. Qualitatively, this does not change anything in their basic expression as "mostly religious" (see table 3.16). With regard to their difference in degree, however, they are at different ends of the spectrum of the fuzzy value 0.75. This difference would be lost by direct calibration. Transformative calibrations, on the other hand, can reflect this difference. This indirect procedure can be realized even with rather little knowledge about the nature of the condition, since it only refers to qualitative similarity and not to concrete values or expressions.

If more detailed knowledge or theories are available the **direct method** can be used. Verkuilen, 2005 recommends the term **assignment by transformation**, since otherwise confusion with the **direct assignment** may occur. However, since the indirect method is also an assignment by transformation, this does not guarantee unambiguousness in the author's opinion. For this reason, the name chosen by Ragin as direct method of calibration should be kept. This process differs from the previous calibration methods in that the cases do not have to be considered individually and judgments have to be made regarding their affiliation and the degree to which they belong to the corresponding set. Instead, three qualitative anchors are defined (cf. Ragin, 2008, p. 90): Complete affiliation, crossover point and complete non-affiliation. Similar to qualitative coding, it is necessary to define the point at which values take on a qualitatively different form (religious vs. non-religious). In addition, the respective end points of the spectrum must also be defined. For this purpose, concrete values must be determined, from which cases are completely assigned to the set or its negation.

Subsequently, the positive or negative deviation from the crossover point is determined for each initial value. For the further steps Ragin converts the verbal labels regarding set membership into mathematical values using the following formula:

$$\text{odds of membership} = \frac{\text{membership degree}}{1 - \text{membership degree}} \qquad (3.6)$$

The degree of affiliation is chosen in such a way that simple values are obtained after logarithmization and the threshold values are obviously based on the 5% error probabilities of classical statistics (0.953 and 0.047).

Table 3.18: Mathematical translation of verbal labels (shortened after Ragin, 2008, S.88)

Verbal label	Degree of membership	Associated odds	Log odds of membership
threshold of full membership	0,953	20,09	3
more in than out	0,622	1,65	0,5
crossover point	0,5	1	0
more out than in	0,378	0,61	-0,5
threshold of full non-membership	0,047	0,05	-3

A scalar is then determined for values above and below the crossover point. This scalar is determined for values above the crossover point as follows:

$$\text{Scalar} = \frac{\text{log odds of threshold for full membership}}{\text{anchor for full membership} - \text{anchor for crossover point}} \tag{3.7}$$

For all values below, the log odds and the anchor value for non-membership are used accordingly. The previously calculated deviations are then multiplied by the scalar and calculated using

$$\mathrm{e}^p/(1+\mathrm{e}^p) \tag{3.8}$$

into membership scores between 0 and 1. where p is the calculated product. Transferred to the five hypothetical cases from table 3.17, the qualitative anchors would be as follows: e = 4, c = 10, i = 17[8]. For case #1, the calculation would therefore be as follows:

$$\begin{aligned} 16-10 &= 6 \\ \frac{3}{17-10} &= 0,43 \\ 6*0,43 &= 2,58 \\ \mathrm{e}^{2,58}/(1+\mathrm{e}^{2,58}) &= 0,926 \end{aligned}$$

For the complete table with all fuzzy set values this results in:

Table 3.19: Sample direct calibration

#	Score	Deviation	Scalar	Product	Membership score
1	16	6	0,43	2,58	0,926
2	6	-4	0,5	-2	0,123
3	4	-6	0,5	-3	0,05
4	19	9	0,43	3,78	0,978
5	12	2	0,43	0,86	0,698

[8] e = exclusion point/threshold non membership, c = crossover point, i = inclusion point/threshold membership

In a direct comparison with table 3.17, direct calibration provides different results despite the use of the same criteria. These can be traced back to the “indirectness” (cf. Ragin, 2008, p. 97) of the first method, which is based on estimates of the underlying regression. However, the resulting fuzzy membership scores are basically similar.

Finally, a few general things about the calibration process should be mentioned.
Calibration is a process which, like the construction of the configuration model, is a highly user-dependent process. By choosing the theories and assumptions involved as well as empirical values, the researcher has a direct influence on decisive variables within the QCA. Especially the decision on the crossover point, which ultimately has a decisive influence on the entire coding process. However, despite theoretical and empirical foundations, calibration also always involves a certain arbitrariness (cf. Skaaning, 2011, p. 394). It is therefore necessary to explain the underlying considerations and steps transparently and to document them in a comprehensible manner (cf. Schneider and Wagemann, 2012, p. 32, Rihoux and Meur, 2009, p. 42). In addition, by changing the values, a form of robustness tests can be performed, which can give conclusions about the quality of the calibration (see chapter 3.3.6).
Smithson and Verkuilen also point out an aspect which has not been considered or communicated in the other theoretical literature on the method and also in practical application so far. The external criteria which are used for calibration are often assumed to have an “objectivity” which they do not (or even can not) have. As with any data collection, systematic or random errors can never be excluded. If, however, these data are then taken as external sample references, they are usually used without looking at such potential problems. And thus it cannot be assumed “that membership assignments are without error” (cf. Smithson and Verkuilen, 2006, p. 31). Therefore, the authors advocate to represent this uncertainty in the membership scores (cf. Verkuilen, 2005, p. 480) and to indicate a “range” of possible SMVs. They design different possibilities for this, for example by means of test inversion or bootstrapping, which are not to be reproduced comprehensively at this point. Ultimately, this results in random scatter ranges/error bands within which the “correct” membership value is expected. Smithson and Verkuilen then suggest to use the lowest and the highest value of these membership scores in further analyses and to observe whether and to what extent the result changes (cf. Smithson and Verkuilen, 2006, p. 36).
Transformative calibrations are attested a problem in some parts of the literature that is called "false precision" (cf. Schneider and Wagemann, 2012, p. 37, Ragin, 2000, p. 167, Kahwati and Kane, 2019, p. 76). By mapping the initial values as “continuous fuzzy sets” (Kahwati and Kane, 2019, p. 73)[9] very fine gradations between the individual cases result. However, whether these differences can be interpreted in a theoretically significant way is doubtful (Ragin, 2000, p. 167). Whether 100 residents or 101 residents live in a care facility and they thus differ by 0.01 within the condition "facility size" with regard to their fuzzy values may play a mathematical role, but it is not a qualitatively significant variance. Therefore, a calibration procedure should always include the question “How much accuracy is required?”.
Closely related to this is the question of which form of calibration should be used when. The cognitive interest and the scale level of the initial data play a role here: crisp sets are therefore mainly used when dichotomies are already present in the selected conditions or are at least obvious (cf.

[9] Contrast to “fixed value fuzzy sets” (see section 3.3.3)

Ragin, 2008, p. 141). The existence of an academic qualification or membership in an club would be examples of this. A differentiation into fuzzy sets of these nominal response categories would not be theoretically justifiable or meaningful. However, crisp sets can also be used if the user is only interested in obtaining information about the general characteristics or the existence of certain factors. If only the presence or absence of a condition is of interest, e.g. for exploratory procedures, differentiation into fuzzy sets would be a form of precision that might not be absolutely necessary because it does not serve the user's scientific interest.

Transformative calibration, on the other hand, is best suited if the underlying values are metric or if complex constructs are to be grasped. The gross domestic product of European countries or the weight of a person can be transformed into fuzzy sets in a qualitatively meaningful way. But also the degree of academization of a person can be mapped. This ordinal data is a useful quantity for fixed value fuzzy sets. A continuous assignment of values would not make sense here either, since there is only a countable, finite set of characteristic values.

Even if the process of calibration offers a lot of openness and thus uncertainty in the research process and is, according to Ragin, "one of the weak points of much of the [...] literature"' (Ragin and Pennings, 2005, p. 427), not too much importance should be attached to the individual fuzzy set score. As long as the qualitative anchor is not exceeded, the results of an analysis remain largely robust (cf. Emmenegger et al., 2014, p. 25, Schneider and Wagemann, 2012, p. 37).

Furthermore, it is important to emphasize once again that at no point a fuzzy value of 0.5, i.e. at the point of maximum ambiguity, may be assigned. Otherwise, this will cause this case to have a maximum value in both qualitative categories in the corresponding property space and therefore cannot be assigned unambiguously within the truth table (vlg. Ragin, 2000, p. 186, Schneider and Wagemann, 2012, p. 28). This will be discussed in more detail in the following section.

3.3.4 Truth tables

After calibration is completed, set membership values for all conditions of the configuration model and for the outcome are available for each of the cases. For the analysis these are transferred into a truth table. As already described in section 3.2.3, it contains all 2^k logically possible combinations of binary conditions. Thus, each row represents a qualitatively different expression, which Ragin equates with the ideal types of Max Weber (cf. Ragin, 2000, p. 191). When creating a truth table, a k-dimensional vector space with 2^k corners is symbolically created. Each border corresponds to a condition and each corner corresponds to a maximum or minimum set membership. Figure 3.6 illustrates this for three conditions. The assignment in a crisp set QCA is done intuitively by comparing the respective SMVs of a case with the ideal types of the truth table. For example, case 1 in the example matrix 3.20 has values of 1 in the conditions "urban location" (A) and "high staffing" (C); in the condition "large facility" (B) a value of 0. Thus the case is assigned to row 4. The same happens with all other cases. The result is shown in table 3.21.

The assignment of fuzzy values in a truth table is comparatively more complex. This is mainly due to the fact that there is usually no clear affiliation to sets. The fuzzy logic allows the simultaneous, gradual affiliation to all sets and their negations simultaneously (cf. Schneider and Wagemann, 2012, p. 27f., Ragin, 2009, p. 100). Table 3.22 corresponds to the previously used table with crisp values. The qualitative expression of the respective conditions across the cases was retained.

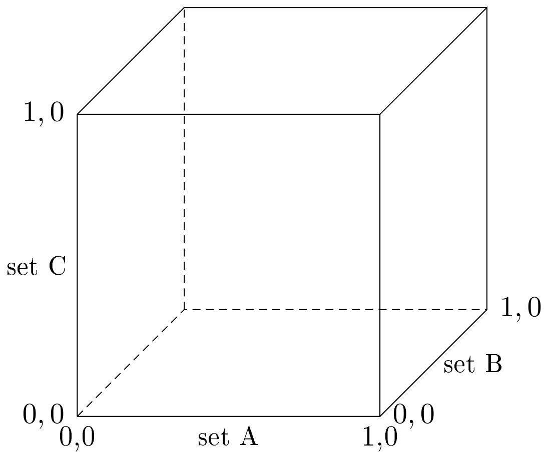


Figure 3.6: Threedimensinal vector space

Table 3.20: Data matrix: crisp

#	Conditions			Outcome
	Urban location	Large facility	High staffing	Frequent falls
1	1	0	1	0
2	1	1	0	1
3	0	0	0	1
4	1	0	0	0
5	0	1	1	0
6	0	1	1	1

Table 3.21: Truth table without outcome

Row	Conditions			Case #
	Urban location	Large facility	High staffing	
1	1	1	1	-
2	1	1	0	2
3	1	0	0	4
4	1	0	1	1
5	0	0	1	-
6	0	1	0	-
7	0	1	1	5,6
8	0	0	0	3

Table 3.22: Data matrix: fuzzy

#	Conditions			Outcome
	Urban location	Large facility	High staffing	Frequent falls
1	0,8	0,25	0,6	0,1
2	0,8	0,8	0,25	0,9
3	0,25	0,25	0,1	0,8
4	0,9	0,4	0,1	0,25
5	0,1	0,6	0,8	0,4
6	0,2	0,7	0,75	0,6

To analyze which ideal type a case corresponds to within the characteristic space, membership values must be calculated for all observed combinations (cf. Duşa, 2020, S. 160). The operations necessary for this were introduced in the section 3.2.3. The corresponding SMVs are: $A = 0.8/a = 0.2; B = 0.25/b = 0.75; C = 0.6/c = 0.4$. Using the Boolean connection AND results in the following fuzzy values for the eight possible combinations of characteristics:

Table 3.23: Fuzzy values of the ideal types for case #1

Case #	ABC	ABc	AbC	Abc	aBC	aBc	abC	abc
1	0,25	0,25	**0,6**	0,4	0,2	0,2	0,2	0,2

Emphasized is the only value that is above the qualitative anchor of 0.5 (*AbC*). This is, due to the mathematical peculiarities (cf. Schneider and Wagemann, 2012, p. 100), only ever the case with one combination of characteristics that represents the strongest affiliation to one of the ideal types.
As mentioned at the end of the previous section, however, this only applies, if no fuzzy value lies directly on the qualitative anchor. If the SMV for C were 0.5 instead of 0.6, the resulting fuzzy values for the combinations of characteristics in case 1' would be as follows:

Table 3.24: Fuzzy values of the ideal types for case #1'

Case #	ABC	ABc	AbC	Abc	aBC	aBc	abC	abc
1'	0,25	0,25	**0,5**	**0,5**	0,2	0,2	0,2	0,2

In this case, both *AbC* and *Abc* have the highest value of 0.5, making it impossible to clearly assign them to an ideal type.
After the complete assignment of all cases from table 3.22, the same truth table as before emerges due to the fact that all values of the two examples are on the same side of the qualitative anchor. Both the csQCA and the fsQCA thus produce truth tables with crisp values. However, this does not represent a transformation into crisp sets (cf. Schneider and Wagemann, 2012, p. 103). The information of the fuzzy values is used to assign the rows of the truth table and to assign the

outcome value. This step is the completion of the creation of a truth table.
In order to assign an outcome value to a row of the truth table, it has to be checked if the cases in the row can be considered as subset and thus as a sufficient condition for the outcome. It must therefore be checked to what extent configuration X has a share in outcome Y. For this purpose, a respective **raw consistency** (cf. Schneider and Wagemann, 2012, p. 129) is calculated and compared against a defined **consistency threshold**. The calculation is performed as the proportion of cases in a row, which also shows the outcome, compared to the total number of cases in this row.
For the crisp set example in table 3.21 there are perfect consistency values for rows 2 - 4 and 8, since they are only assigned to a single case. Row 7, on the other hand, is assigned to two cases with different outcome values: In case 5, the outcome is not present, while in case 6, despite the same conditions, it occurs. These **contradictions** reduce the consistency of the assumption that the configuration is sufficient for the outcome to occur. Mathematically, this is calculated as the quotient of the number of cases where condition or configuration X and outcome Y are present and the total number of cases where X is present:

$$Consistency_{crisp} = \frac{n_{X=1,Y=1}}{n} \tag{3.9}$$

With reference to table 3.7, the cases in the allowed cell are divided by the sum of the cell "allowed" and "not allowed". The more non-permitted discrepancies there are, the less consistency there is. In this case, the allowed case 6 is divided by the two existing cases 5 and 6, giving a consistency value of 0.5. Due to the fact that only half of the empirical cases are associated with the outcome, only a weak sufficient relationship of the configuration with the outcome can be assumed. Similar to classical statistics, there is no absolute value for the point at which a sufficient subset relationship can be assumed. But a value of no less than 0.75 is suggested in the literature (cf. Ragin, 2008, p. 46/136, Schneider and Wagemann, 2012, p. 279). However, this threshold value can be changed depending on the type of investigation, if there is sufficient justification for this (cf. Kahwati and Kane, 2019, p. 114).
This form of calculation has the disadvantage, however, that it cannot take into account how much a value deviates. Since crisp sets have only two values, such an "all or nothing" method has no negative effects (cf. Smithson and Verkuilen, 2006, p. 11). In the case of fuzzy sets, however, such a procedure would mean that even a minimal exceeding of the membership score of the outcome would have a strong negative impact on the consistency value (cf. Smithson and Verkuilen, 2006, pp. 11+65). For fuzzy values, the row consistency is therefore calculated using the following formula:

$$Consistency_{fuzzy} = \frac{\sum_{i=1}^{I} min(X_i;Y_i)}{X_i} \tag{3.10}$$

For each case of the entire sample, the minimum values of membership score in the corresponding row and score of the outcome are added up. This also applies to cases that have not exceeded the 0.5 mark in the allocation process and therefore are not actually allocated to this row of the truth table (cf. Ragin, 2008, pp. 52f. Ragin, 2006, p. 7,Schneider and Wagemann, 2012, p. 126,Kahwati and Kane, 2019, p. 111). This becomes necessary because fuzzy sets of each configuration allow a partial membership in each ideal type of the feature space. This sum is then divided by the sum

Table 3.25: Calculation of consistency for row aBC

Case	SMV aBC	Outcome Y	min(aBC, Y)
1	0,2	0,1	0,1
2	0,2	0,9	0,2
3	0,1	0,8	0,1
4	0,1	0,25	0,1
5	0,6	0,4	0,4
6	0,7	0,6	0,6

Table 3.26: Truth table with outcome

	Conditions				
Row	Urban location	Large facility	High staffing	Outcome	Case #
1	1	1	1	-	-
2	1	1	0	1	2
3	1	0	0	0	4
4	1	0	1	0	1
5	0	0	1	-	-
6	0	1	0	-	-
7	0	1	1	1	5,6
8	0	0	0	1	3

of the membership scores of all cases in the considered configuration. The less frequently and less the outcomes score is exceeded, the closer the value tends to 1 and the better the consistency. For row 7 of the truth table 3.21, the SMVs of the cases in the combination of characteristics and the outcome as well as the respective minimum value were given in table 3.25. For the consistency the following results are obtained:

$$Consistency_{aBC} = \frac{0,1+0,2+0,1+0,1+0,4+0,6}{0,2+0,2+0,1+0,1+0,6+0,7} = \frac{1,5}{1,9} = 0,789 \tag{3.11}$$

Despite contradictions, row 7 can therefore still be considered sufficient for the outcome and would be coded as 1.
After all outcome assignments have been completed, a complete truth table is available for further analysis.

3.3.5 Analysis

Before the actual analysis process begins with the examination for sufficient and necessary conditions, in almost all cases of work with real data, preparations must be made on the truth table.

Contradictory rows

The problem of contradictory rows has already been addressed in the outcome assignment. It occurs when in the empirical data the same configuration is responsible for both the occurrence and the absence of the outcome, i.e. the tendency of a combination of characteristics is unclear (cf. Ragin, 1987, p. 113). Contradictions are a helpful indicator for the user and are not merely annoying. They can indicate that the selected conditions are not able to sufficiently separate the cases or that the underlying theory for their selection is flawed (cf. Delreux and Hesters, 2010, pp. 5f.). In the case of consistent tables, it is therefore probable that there is a basic assumption about the relationships between conditions and outcome that is consistent with the empirical data and thus has substance. A way of dealing with such rows has already been described above. By weighing up the consistency value, deviating cases can be regarded as outliers or measurement errors and ignored. However, because of its origin in the comparative, case-oriented methodology, the QCA also offers a number of qualitative approaches to the solution.

Without making any major changes to the previous table, the **coding** of all outcomes of the conflicting rows can basically be set either to "0" or "1" (cf. Rihoux and Meur, 2009, p. 48f.,Schneider and Wagemann, 2007, p. 117, Kahwati and Kane, 2019, p. 114). Behind the coding with "0" there is the assumption that there is no clear tendency which connects the occurrence of the configuration with the presence of the outcome. To avoid wrong conclusions at the end of the investigation, these options are eliminated from the further process. This conservative approach is countered by the equally valid logic that there are certainly instances in which the combination under consideration leads to the outcome and such rows should therefore be included in the analysis. Here, in order to achieve a broader coverage of all possible solutions, it is accepted that even possibly erroneous cases are included in the analysis.

Schneider and Wagemann also describe the possibility of using software to determine the "best possible" coding of contradictory series. The decision criterion here is whether a considered row contributes to a parsimonious solution by inclusion ("1") or exclusion ("0") (cf. Schneider and Wagemann, 2007, p. 117). However, since such a procedure has hardly any substance in terms of content and is a pure thought experiment, the authors reject this procedure as "least justifiable"' (Schneider and Wagemann, 2012, p. 122).

Beyond these approaches, other measures can be taken to resolve contradictions. Here the iterative character of the QCA becomes clear. Thus, changes can be made to all steps discussed so far:

The structure of the **configuration model** can be changed. By adding conditions, contradictions can be solved if the corresponding cases differ in the expression of this condition. Of course, it must be possible to justify such a change in terms of content and the new condition must be able to be inserted into the model. Moreover, more conditions can also raise new problems, such as the randomly high consistency values already described (see section 3.3.1) and limited empirical diversity (see section 3.3.5). The omission of a condition can also be a option, since it can change the structure of the whole truth table. Here, too, a consideration must be made as to whether the loss of a condition is theoretically justifiable.

Rihoux and de Meure suggest that the **outcome** itself can also be changed (cf. Rihoux and Meur, 2009, p. 49). However, this will be problematic in many cases, as the focus of the investigation may have to be completely changed or data may have to be collected anew. However, the authors make this recommendation based on their own experience, in which one outcome condition could be divided into two opposing subconditions that produced fewer contradictions (cf. ibid.).

In addition, the **population** can also be redefined or defined differently (cf. Schneider and Wagemann, 2012, p. 121). By changing those criteria, cases that formerly caused contradictions could move in other rows of truth table because now they belong to another configuration. The exclusion of individual cases is also possible, but must not be done mechanically, just because it generated

contradictions. Here, too, it must be theoretically weighed up whether an exclusion is justifiable.
A last possibility is to change the **calibration**. If other reference values are consulted or the qualitative assessment of borderline cases is changed, contradictions can under certain circumstances be solved by the fact that the problematic cases now belong to a different row of the truth table (cf. Rihoux and Meur, 2009, p. 49, Kahwati and Kane, 2019, p. 116).
Of course, the measures described do not necessarily lead to success, since their applicability is not guaranteed in every case. However, they should be considered, as they are directly related to the qualitative origin of the method. For further analysis, however, 100% consistent rows are not necessary and not expected in empirical data. For this reason, in practice, the quantitative method using a consistency value is mainly used.

Frequency thresholds

Another decisive factor for the analysis is the composition of the individual rows of the truth table with cases. Thus, the question arises whether a statement about a necessary condition is sufficiently substantiated if it is based on a single, empirical instance only, or whether several cases are necessary. In principle, it does not contradict the inherent logic of case-oriented methods to also ascribe a corresponding significance to a single case (cf. Ragin, 2000, p. 116), since there, methodologically speaking, the general is to be extracted from the particular. Also in QCA, the number of the respective cases is not directly included in the analysis and plays a clearly subordinate role compared to classical statistics (cf. Ragin, 1987, p. 88).
In certain cases, however, it may be necessary and useful to define a frequency threshold for the rows of a truth table. The reasons given in the literature for this are mainly measurement errors or allocation/calibration errors (cf. Ragin, 2009, p. 107, Ragin, 2008, p. 133). Especially for applications in the range of medium and higher case numbers, threshold values of 3 and more cases per row are postulated in order to define a configuration as meaningful enough (cf. Schneider and Wagemann, 2012, p. 153). This exclusion of weakly populated table rows prevents on the one hand that possible measurement errors are entered into the analysis, but on the other hand it also prevents that rare but interesting configurations are captured. Here, too, a consideration must be made as to how far a higher cut-off point can be justified. The scientific interest can also have an influence on this decision. Especially for deductive model tests the inclusion of small special cases can be a hindrance (cf. Emmenegger et al., 2014, p. 66) and a higher threshold would be chosen. All rows for which this value is not reached are coded with "0", even if the necessary consistency value would be reached. However, the study by Emmenegger et al. also showed that the choice of a frequency threshold has only a minor influence on the analysis of large data sets and the results remain largely stable (cf. Emmenegger et al., 2014, p. 22)[10].

[10] The situation that the problem of measurement errors is mainly discussed with higher case numbers could be explained by the fact that with small case numbers the user is expected to have a sufficiently deep knowledge of the individual cases to exclude serious errors. An investigator who has a profound knowledge about the empirical situation he is analyzing is probably more likely to notice cases with impossible values of conditions. Returning to the example of organizational factors in nursing homes: Finding a facility that provides special care for ventilated residents but doesn't employ at least one nurse with specialized ventilation training could be deemed to be a measurement error, for it would violate §11 of the LPersVO. On the other hand it could also point to a special case, where there IS a deviation from the "usual". Excluding cases because of suspected measurement errors can therefore be a doubled-edged sword.

Limited diversity

A special case is when there are no empirical cases for one or more rows of the truth table. This is the case, for example, for rows 1, 5, and 6 in table 3.21. The sample does not contain cases that could be assigned to the configurations ABC, abC or aBc in their ideal type. In such a case one speaks of **logical remainders** (cf. Schneider and Wagemann, 2009, p. 401) or more generally of the problem **limited empirical diversity**.
Ragin and Sonnett summarize, not without a wink:

If the empirical world would only cooperate and present social scientists with cases exhibiting all logically possible combinations of relevant causal conditions, then social research would be much more straightforeward (Ragin, 2008, S. 147).

The causes of this limitation can be divided into three forms: **arithmetic, clustered and impossible remainders**.
Arithmetic remainders can be explained by the already described structure of a truth table: The number of its rows results from all 2^k logically possible combinations of the conditions. If this number now exceeds the number of cases within a sample, it is not possible to occupy all rows of the table. Due to the exponential growth and the tendency to apply QCA to rather limited numbers of cases, limited diversity is the rule rather than the exception(cf. Schneider and Wagemann, 2012, p. 160, Ragin, 2008, p. 163).
Clustered remainders take into account the fact that social constructs do not necessarily occur equally often in all possible combinations of characteristics, or in some cases not at all. In many cases, characteristics are present in fixed combinations. A long, quasi universal, valid example is the combination of "head of state" and "male". Until 1980 all elected heads of state were part of this set. Only with the election of Vigdis Finnbogadottir in Iceland[11] there was an empirical case for another, empirical clustering. This form of logical remainders is often conditioned by historical, social, cultural or other processes, but can also be the expression of a causal relationship between two conditions (cf. Schneider and Wagemann, 2012, pp. 154f., Ragin, 2000, p. 81). For example, if condition A is only present if condition B is also present and there are no cases in which A is not present, there are good reasons to assume that it is a necessary condition. However, due to the fact that such clusters can always be based on a social dimension (as in the example of male heads of state), no premature conclusions should be drawn without further analysis.
Impossible remainders, on the other hand, are those where the occurrence of the combination of characteristics is empirically impossible, such as the pregnancy of a biological male. In order to obtain such a combination of characteristics, a radical change in the current reality would be necessary (cf. Schneider and Wagemann, 2012, pp. 156f.). Herein lies the difference between clustered and impossible remainders: While the former are conceivable in principle and are not empirically available only because of barriers or fundamentally more rarely occurring cases, the latter are simply not within the realm of possibility in the current situation.
For the further analysis, a decision must be made if there is limited empirical diversity. On the one hand each of these rows can be excluded, the conservative approach, or on the other hand a theoretical outcome can be determined for each row. This process is called **counterfactual analysis**.

[11] http://www.demokratiezentrum.org/themen/genderperspektiven/pionierinnen/pionierinnen-politik-gallery.html?index=1507

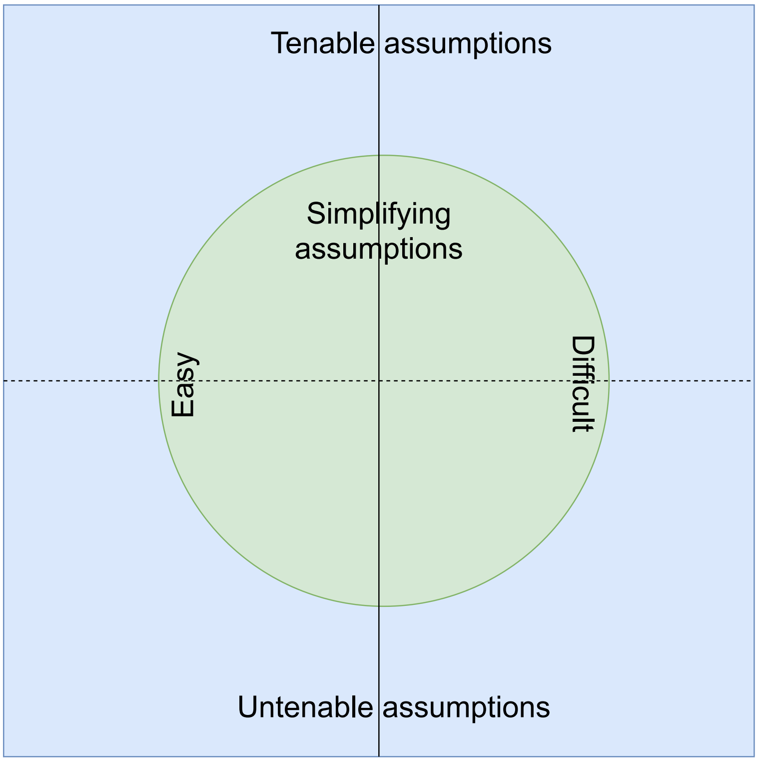


Figure 3.7: Forms of counterfactuals

It allows for a further inclusion of theoretical knowledge in order to make the solutions of a QCA more parsimonious under certain circumstances.

Counterfactual analysis can be summarized as the assumption of a plausible outcome for a combination of conditions that is not empirically available (cf. Ragin, 2008, p. 150). Specifically, the example used here would therefore require assumptions about the extent to which, in row 1 of the truth table, the presence of a large facility in an urban location with a large number of staff has an effect on the outcome of "frequent falls". The same is true for facilities that are neither urban nor large but have a lot of staff (row 5) or large facilities without a lot of staff and not in an urban location (row 6). The assumptions made for this can be divided hierarchically into different categories. These will be explained using figure 3.7.

Basically, tenable and untenable assumptions can be distinguished from each other. Untenable assumptions are either **implausible** or **incoherent**. The first category includes all those rows of the truth table which are also to be considered as impossible remainders. So all those cases in which a combination of the conditions is not possible or not imaginable in reality. To integrate such assumptions into the QCA solution therefore inevitably leads to erroneous results and must be avoided. The corresponding row must therefore be excluded from the analysis.

Incoherences occurs, for example, if a condition A is recognized as necessary for the outcome, but its complement a is then assumed to be sufficient for the outcome in a remainder row. This contradicts the empirical finding of the necessity of A and must therefore not be included as an assumption in the analysis. Another form of incoherent assumptions is the simultaneous sufficient effect of a configuration on the outcome and its complement. A solution abC must therefore not be assumed for both Outcome Y and y. This contradicts logic and such assumptions must not be included in the generation of the solutions.

Within the tenable and untenable assumptions there is a subset which is simplifying for the solutions of a QCA[12]. By including these assumptions about unobserved cases, it is possible to reduce the complexity of the solution term. If one decides to use these counterfactual elements, the QCA follows a path that goes beyond the descriptive evaluation of empirical data (cf. Meur et al., 2009, pp. 153f.).

A further distinction is made between **easy** and **difficult counterfactual elements**. This depends on the theoretical plausibility or the **directional expectations** (cf. Schneider and Wagemann, 2007, p. 108). Ragin illustrates this very well with an example: The available data shows that the conditions A, B, C and d are sufficient for the existence of the outcome. Configuration $ABCD$, which would be necessary for simplification, is not supported by empirical cases, i.e. a remainder. However, theoretical considerations and other results suggest that $ABCD$ leads to the outcome. This well-founded assumption allows the inclusion as a simple, counterfactual element, since it is consistent with external knowledge and does not contradict the data (cf. Ragin, 2008, p. 160ff.). Conversely, a difficult counterfactual element would be one that is contrary to theoretical and substantive knowledge. If in another case the configuration $ABCD$ would be sufficient for the outcome, the investigator assumes that D is redundant for the solution, but there are no empirical cases of $ABCd$ that would allow minimization, "[e]xisting theoretical and substantive knowledge" (Ragin, 2008, p. 162) must be used here as well. However, if this indicates that the presence of D under the further conditions ABC is responsible for the presence of Y, the inclusion of $ABCd$ as a simplifying element would be a difficult counterfactual. This does not mean that such assumptions should be excluded right away, but there must be an extremely strong rationale behind why this is assumed, contrary to existing theories or empirical data (cf. Ragin, 2008, p. 162).

Some assumptions that can be made regarding remainders are basically tenable, but do not have a simplifying effect on the solution term. However, theoretical or substantial knowledge still justifies the use of such **non-simplifying assumptions** in the analysis. This leads to the point that although the solution is less parsimonious and more complex to interpret, at the same time it includes a larger body of knowledge (cf. Kahwati and Kane, 2019, p. 149). Here it is up to the user and the intention of the work whether such factors should be included in order to produce a solution that is as comprehensive as possible, or whether above all a term that is as condensed as possible should be produced.

Necessary conditions

Once the preparations are complete, the identification of sufficient and necessary conditions can then begin. The basic concept for this was already explained in section 3.2.4. At this point, therefore, the analysis of a truth table will be dealt with directly and concretely, and XY plots will be introduced as a further possibility to determine relations between subsets.

In the QCA, the analysis of necessary conditions should always be carried out **before** the analysis of sufficient conditions (cf. Ragin, 2000, p. 106, Schneider and Wagemann, 2007, p. 113,Schneider and Wagemann, 2012, p. 231). This is particularly necessary when counterfactual assumptions are included. Due to the (unintentional) use of incoherent assumptions, it is possible that the analysis of sufficient conditions may exclude those that are identified as necessary in an isolated consideration.

[12]How the minimization or simplification works in detail is discussed in the section 3.3.5

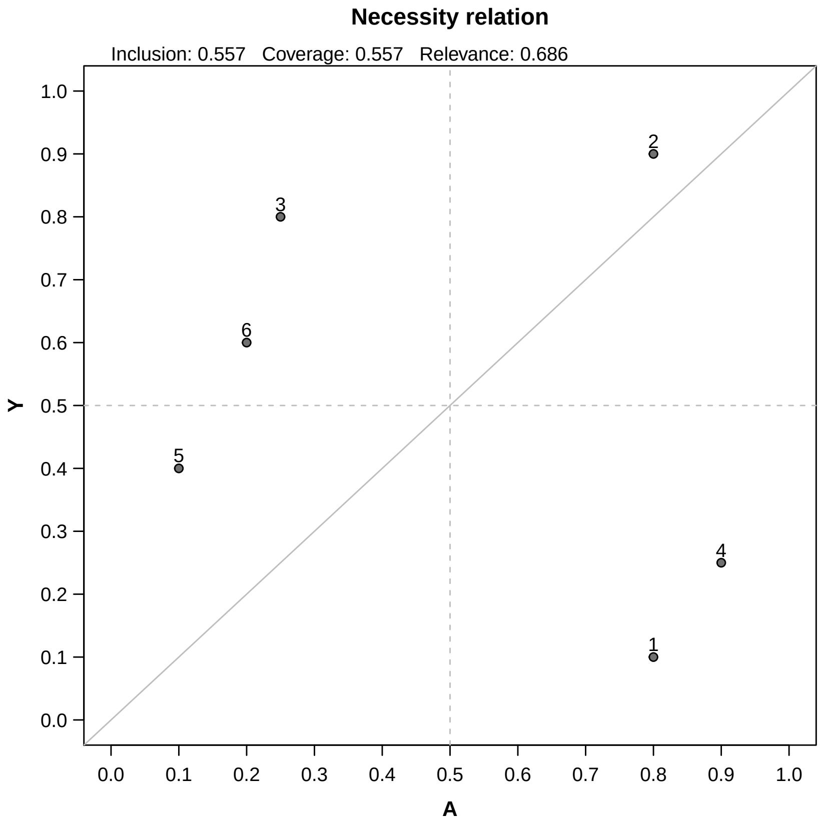


Figure 3.8: XY-plot: $A \leftarrow Y$ from table 3.22

If such a case of **hidden, necessary conditions** occurs, the processes in the counterfactual analysis must be checked and untenable assumptions must be excluded.
Another possibility is to add the necessary conditions subsequently to any sufficient solution path, should they have been omitted in the minimization (cf. Ragin, 2000, p. 254). In this way, however, untenable assumptions remain in the solution path and the calculated robustness values (see section 3.3.6) lose their validity, because they would have to be calculated again for the newly created solution. This makes this method quiet inconvenient and no examples were found, where it was actually used. A clearly better way is to eliminat untenable assumptions in advance.
Necessary conditions can first of all be identified by means of the truth table. In doing so, all cases in which the outcome is present are considered and conditions are sought that also always occur in such cases (cf. Caramani, 2009, pp. 59f.). In table 3.26, for example, the condition "large facility" appears in rows 2 and 7 together with the outcome. If one would just focus on these two rows, it would argue for a necessary condition. In row 8, however, the outcome is present without being a large facility. In a veristic approach, the assumption of *large facility* $\leftarrow$ *frequent falls* would be refuted. Since the outcome of necessary conditions must be a subset of the corresponding condition, an evaluation can also be done graphically using a **XY Plot**. The set-membership values of the outcome and the condition to be tested are plotted on two axes. If the SMVs of the condition within the cases exceed those of the outcome, or: if $Y_i \leq X_i$ applies, then a subset relationship of the outcome to the condition can be assumed. This is shown as an example for condition A from table 3.22 in figure 3.8. In order to meet the requirements, all cases would therefore have to lie below the diagonal in the necessity area. The greater the distance to the diagonal, the more unambiguous

or stronger the relationship (cf. Schneider and Wagemann, 2012, p. 141). The example shows that **only two out of six cases** lie on the "right" side of the axis. It therefore can not be interpreted as necessary for the outcome.
However, as with the assignment of an outcome for contradictory rows, a "softer", probabilistic approach can be chosen. For this purpose, the consistency value is used again as an aid. It is calculated similarly to the formula 3.10:

$$Consistency_{necessary\,conditions(X_i \geq Y_i)} = \frac{\sum_{i=1}^{I} min(X_i;Y_i)}{\sum Y_i} \tag{3.12}$$

The membership scores of all cases where it is true that $Y_i \leq X_i$ are divided by the sum of the scores in Y (cf. Ragin, 2006, p. 7f). The resulting value between 0 and 1 indicates how consistent the statement "X is a superset of Y" or "X is a necessary condition for Y" is. In figure 3.8 the values necessary for the interpretation of the results are given above the plot. Instead of "consistency‘" the R package "QCA" chooses the term **inclusion** because it represents the degree to which the subset is "included" into the superset (cf. Duşa, 2020, p. 117). The two remaining values are explained in section 3.3.6.
As before, there is no objective limit to the consistency value of a necessary condition. In his original work (Ragin, 2006) Ragin himself does not name a threshold value, but it becomes clear that in his examples he orients himself by a limit that is very close to 1. Later he speaks of a "high consistency threshold of necessary conditions" (Ragin, 2009, p. 118). In any case, the current literature agrees that high demands should be placed on the concept of a necessary condition. Thereby, a consistency value should not be below 0.9 (cf. Schneider and Wagemann, 2012, p. 143, Kahwati et al., 2016, p. 122).
In contrast to sufficient conditions, the search for necessary conditions is carried out separately for each condition and not in conjunction. This process is a purely logical consequence of Boolean algebra, since the connection by AND uses the **minimum aggregation principle** (see section 3.2.3). However, since the SMVs must be greater than or equal to the values of the outcome in order to be considered necessary, conditions that have individually failed a test for necessity will never be able to exceed the threshold, even in conjunction with other conditions.

Sufficient conditions

In the following step the sufficient conditions are analyzed. For this purpose, mirrored to the previous procedure, it is checked whether the following applies: $X_i \leq Y_i$, the case membership values in the condition are less than or equal to the membership values in the outcome. So there should be no cases in which the condition exists without the outcome (cf. Caramani, 2009, p. 56). The formula for the calculation is therefore:

$$Consistency_{sufficient\,conditions(X_i \leq Y_i)} = \frac{\sum_{i=1}^{I} min(X_i;Y_i)}{\sum X_i} \tag{3.13}$$

Compared to the consistency of necessary conditions only the divisor changes to X_i. Again, the display can be done using XY plot. For condition B it can be seen that only the cases 2 and 3 are above the diagonal from (0,0) to (1,1) and therefore in the sufficiency area. The remaining cases

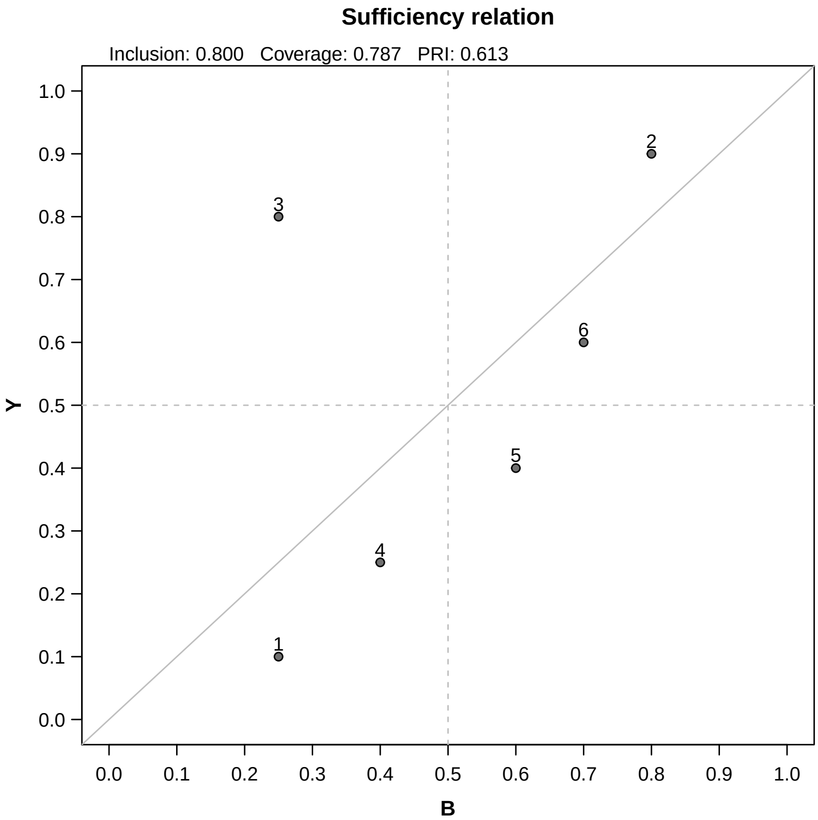


Figure 3.9: XY-plot: $B \rightarrow Y$ from table 3.22

are below this line, but are relatively colse to it. This is reflected in a rather high consistency value of 0.8. In contrast to necessary conditions, weaker relationships to the outcome can be tolerated here, since the significance of a sufficient condition is not comparable to that of a necessary one. A frequently cited threshold value for acceptance here is 0.75 (cf. Ragin, 2008, pp. 46/136, Schneider and Wagemann, 2012, p. 279). According to this, B would thus be acceptable as a sufficient factor and would be part of the solution. Here the XY-plot can show its strength. Even though the numbers speak for an inclusion of B, the diagram shows, that online 1/3 of the cases **explicitly** support the claim $B \rightarrow Y$. In this case the investigator can ponder if he should really treat B as sufficient from a theoretically-substantive perspective, instead of simply following mathematical results.
In the following, one could continue this procedure for each of the $3^k - 1$ logically possible combinations of conditions and their complements. Until all lines of the truth table in which Y is present are covered (cf. Schneider and Wagemann, 2007, p. 56). Schneider and Wagemann present this as a "bottom-up" procedure (cf. ibid.). However, this is contrary to the basic assumptions of the QCA. Single factors are the starting point, which are only supplemented by conjunctions if their individual significance is not given. Qualitative Comparative Analysis, however, starts out from the assumption of causal complexity, which it then simplifies only afterwards (cf. Vaisey, 2009, p. 310). In practical terms, the enormous effort required to search through all possible combinations also plays a role. Nevertheless, the statements made in this way do not contradict the empirical data and are correct.
However, in order to take the theoretical foundations of the method into account, a different procedure is used: By calculating the **raw consistency** of the rows of the truth table (see section

3.3.4), statements have already been made about which configurations are considered sufficient for the outcome. Therefore, the corresponding rows are now just connected with each other using the Boolean operator OR. The resulting solution is called **conservative solution** or **complex solution** (cf. Ragin, 2009, p. 111).
This solution for table 3.21 would look like the following:

$$ABc + aBC + abc$$

It is crucial that only those rows are included in this formula that are regarded as sufficiently consistent for the production of the outcome and that no logical remainders are included (cf. Kahwati and Kane, 2019, p. 127).
Verbalised such a solution would mean: "Frequent falls occur in large, urban care facilities without much staff; in large, non-urban facilities with a lot of staff or in non-urban, non-large facilities without much staff[13]".
This conservative approach may be difficult to interpret due to many conditions. However, Boolean algebra and QCA offer some approaches to simplify solutions.

Minimization

One such way is the **minimization process**. It uses the **Quine-McClusky algorithm** to create a "pairwise merge" (cf. Schneider and Wagemann, 2007, p. 69) to produce greater parsimony. The following applies:

> *If two Boolean expressions differ in only one causal condition yet produce the same outcome, then the causal condition that distinguisches the two expressions can be considered irrelvant and can be removed to create a simpler, combined expression (Ragin, 1987, S. 93).*

Thus the individual expressions of a solution term are considered, which are also called **primitive expressions** (cf. Schneider and Wagemann, 2012, p. 105). For the truth table from table 3.22, however, it turns out that no further reduction is possible this way, since all expressions differ in more than one condition. For further simplification, logical remainders must be included here (see section 3.3.5).
Therefore, the minimization process will be illustrated using the following example:

$$abc + aBC + aBc + aBC + AbC \rightarrow Y$$

The expressions abc and abC differ only in the different form of C. In terms of content - if we stay true to the previous example - it does not matter whether an institution has a lot of staff. Nevertheless, the absence of A (urban location) and B (large facility) will cause the outcome Y (frequent falls). Condition C can therefore be removed. The same applies to aBc and aBC. Here too, the value of C is irrelevant. After this first pass, the solution can therefore be reduced to the following term:

$$ab + aB + aBc + AbC \rightarrow Y$$

In a second step the expressions ab and aB can be reduced with respect to the condition B and one gets the solution:

[13] The assumption of asymmetry often results in bulky constructs in a verbal presentation of solutions. However, it is important to point out that, for example, "non-urban" is not synonymous with "rural"!

Table 3.27: Prime implicant chart after (Schneider and Wagemann, 2012, S. 70)

	Primitive expressions			
Prime implicants	ABC	ABc	aBC	abC
AB	x	x		
BC	x		x	
aC			x	x

$$a + bC \rightarrow Y$$

Verbalised, therefore, frequent falls occur in non-urban facilities, or in non-large facilities with high staffing. In contrast to the conservative solution, such a result is much easier to grasp and interpret. Any solution that results from minimization is a superset of the conservative solution because it is derived from it (cf. Ragin, 2008, p. 165). The remaining expressions, which cannot be further minimized in the way described, are now called **prime implicants** (cf. Ragin, 1987, p. 95,(Schneider and Wagemann, 2007, p. 70),Caramani, 2009, p. 73).

Redundant prime implicants

Although prime implicants cannot be further simplified with the current approach, this does not mean that they are free of redundancies. Even after minimization primitive expressions can still covered by several prime implicants. The solution term can be further simplified by eliminating such redundant implicants.
Consider the following example:

$$ABC + ABc + aBC + abC \rightarrow Y$$

By the first step of the Quine-McClusky algorithm the main implicants $AB + BC + aC$ can be identified. They each imply two primitive expressions, which are merged in them in pairs (cf. Schneider and Wagemann, 2007, p. 70). AB thus covers both ABC and ABc. A prime implicant is now redundant, if all primitive expressions can be covered even without it (cf. Ragin, 1987, p. 97,Caramani, 2009, p. 74). A **prime implicant chart** is used for this analysis. The prime implicants and the primitive expressions are listed in it (see table 3.27). As can be seen, BC represents a redundancy. Both the primitive expressions ABC and aBC are already covered by the other two prime implicants, so BC can be omitted from the solution. Thus, the original one can be reduced even further:

$$AB + aC \rightarrow Y$$

The resulting solution cannot be further reduced and is the most parsimonious form of this QCA solution.

Negated outcome

Qualitative Comparative Analysis, as described above, assumes an asymmetry in the relationship between the factors. This also means that the solutions for the non-occurrence of an outcome are not simply a inversion of the solutions for the occurrence of the outcome, but qualitatively different events. These events must therefore be analysed separately.

Often it makes sense or even is it necessary to use different theories or external knowledge than used in the first analysis. To use the previous example, the reasons for the **absence** of a fall event may be fundamentally different from those for frequent falls in nursing homes. The previously chosen conditions may be invalid and have no explanatory power for the new outcome, and a completely new truth table must be created (cf. Schneider and Wagemann, 2012, p. 113). This is the decisive difference to correlative methods and theories in which symmetry is assumed and the complement of an event is expressed by the complement of its causal variables (cf. Ragin, 2008, p. 15).
However, if it can be reasonably assumed that the same conditions can also be applied to the absence of an outcome, a simplified form of solution finding can be carried out using the **de Morgan's Law**. Formally (Weisstein, nd) the following applies here:

$$\begin{aligned} \overline{A} \cup \overline{B} &= \overline{A \cap \mathrm{B}} \\ \overline{A} \cap \overline{B} &= \overline{A \cup \mathrm{B}} \end{aligned} \tag{3.14}$$

where $\cup$ corresponds to the Boolean operator "OR" and $\cap$ to "AND" and conditions with an overscore are to be understood as negation. All existing conditions are thus transformed into their complement, and the operators are swapped. If the necessary conditions were met, the solution $AB + aC \rightarrow Y$ from the previous section could be converted to:

$$\begin{gathered} (a + B)(A + c) = \\ Aa + ac + AB + Bc = \\ ac + AB + Bc \rightarrow y \end{gathered}$$

Since Boolean expressions are governed by the associative, distributive and commutative laws of algebra (cf. Schneider and Wagemann, 2012, p. 48), the brackets can be multiplied out and the expression Aa, which is a redundancy in itself, can be shortened.
Beyond the theoretical level, however, it is additionally necessary for the application of de Morgan's Law that there is no limited diversity (cf. Schneider and Wagemann, 2007, p. 128). This results from the fact that the union set from the outcome and its complement always results in the total set ($Y + y = total$) (cf. ibid.). However, with unoccupied rows of the truth table no reliable statement about the assignment to the outcome Y or y can be made. Since logical remainders are a very common phenomenon, their applicability is very limited.
The hurdles are therefore very high, both from a theoretical point of view and from the nature of the data, and thus the early view of Ragin that this is a "convenient shortcut for minimizing negative instances" (Ragin, 1987, p. 99) can by no means be shared.

Solutions

In principle, the QCA knows three forms of solutions: **conservative, intermediate and parsimonious solutions**.
Conservative solutions have already been explained earlier in section 3.3.5: They are based only on the empirically available data of the truth table. All empirically occupied rows that are considered sufficient for the production of the outcome can be connected using the "OR" operator and interpreted as the most complex explanation. The strength of this approach is that all equifinal solutions represented in the data are mapped. Assumptions about non-empirical cases, which could

be faulty or not justifiable, are excluded. On the downside, this merely results in a description of the data. Possibilities of making predictions or drawing conclusions beyond the selected population are not made possible. **Parsimonious solutions** are formed in the literature, especially in earlier works, in such a form that in the case of existing logical remainders, it is examined which form leads to further possibilities of minimization (cf. Rihoux and Meur, 2009, p. 60f., Schneider and Wagemann, 2012, p. 204, Kahwati and Kane, 2019, p. 128).

Thus, if the solution $ab + AB \rightarrow Y$ is present and empirical information about the configuration Ab is missing, an unrestricted concentration on parsimony would cause the analysis algorithm of a software to assign the outcome 1 to this as well, since a further reduction to $b + AB \rightarrow Y$ would then be possible. Again, it has already been noted that this can lead to serious problems in the validity of the results. The fixation on condensed solution terms also means that it is accepted that untenable assumptions can be included in the minimization process which are contrary to any theoretical and practical knowledge.

Schneider and Wagemann counter this problem with the **Enhanced Standard Analysis (ESA)** or **Theory-Guided Enhanced Standard Analysis (TESA)** (Schneider and Wagemann, 2012, p. 200/212). The procedure of both methods is ultimately very simple: ESA already excludes in the **preparation** of the Standard Analysis (SA)[14] all untenable assumptions from the minimization (cf. Schneider and Wagemann, 2012, p. 209). Thus all solutions are based on theoretically justifiable assumptions.

The TESA, on the other hand, additionally drops the premise of parsimony and includes remainders that are non-simplifying (cf. Schneider and Wagemann, 2012, p. 212). Normally these would be omitted in a conventional analysis.

In the eyes of the author, this is the only way to apply the QCA in a meaningful way. Building a solution path on untenable assumptions that only serves to minimize the solution term inevitably leads to unreliable results. In this context, even a single one is enough to raise serious doubts about the validity (cf. Schneider and Wagemann, 2012, p. 218). Likewise, the omission of theoretically significant configurations does not seem stringent for a method whose processes are strongly focused on exactly such external, substantial knowledge. Concentrating on a solution that is parsimonious under all circumstances bears risks that cannot be offset by the advantages.

Between both poles there is the possibility of producing **intermediate solutions**. These are characterised by the fact that they are on the one hand a subset of the parsimonous solution and on the other hand a superset of the conservative solution (cf. Ragin, 2008, p. 166). From both ends of the complexity continuum solutions are formed, which on the one hand are more complex than the parsimonious, but on the other hand are more parsimonious than the most complex. For this purpose only those logical rudiments are used for minimization, which can be regarded as simple **and** simplifying, counterfactual elements. Thus Ragin meets the problem of the inevitable inclusion of difficult counterfactuals in the parsimonious solution, whose interpretation in its original form (without (T)ESA) is only very cautiously possible (cf. Schneider and Wagemann, 2012, p. 171).

As an example, a parsimonious and a conservative solution are given (Figure 3.10). The rules for creating an intermediate solution are now as follows: **First** one may only remove those conditions from a conservative solution that are not present in the most parsimonious solution. **Second** one

[14] This term is used by Ragin and Sonnett to subsume the analysis of a truth table in the presence of logical remainders.

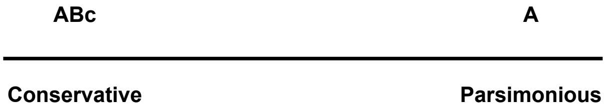


Figure 3.10: Solution continuum after Ragin, 2008, S. 164

may only remove those conditions that are in accordance with the directional expectations (cf. Ragin, 2008, pp. 165f., Schneider and Wagemann, 2012, p. 172). In the present case, this means that with respect to rule one, two intermediate solutions are possible. From the conservative term, once c and once B can be omitted. Since A is the most parsimonious solution, dropping this condition is not allowed. However, if there were reasonable assumptions that the existence of C would lead to the outcome, the intermediate solution Ac would contradict this. This would not be allowed under the second rule and thus only the intermediate solution AB could be justified.

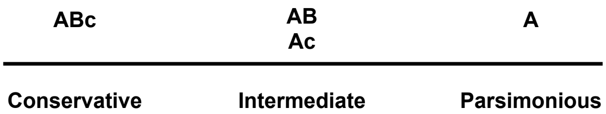


Figure 3.11: Solution continuum with intermediate solution after Ragin, 2008, S. 166

For the creation of such a solution path it is not necessary to formulate directional expectations for each condition. Depending on the expectations used, this results in different solutions, which all have validity, since they are based on the information of a common truth table and are each in a subset/superset relationship to each other (cf. Ragin, 2008, p. 166, Schneider and Wagemann, 2012, p. 174). This special feature, that the minimization results in several solution options, is called **model ambiguity** (cf. Kahwati and Kane, 2019, p. 151). This phenomenon, which is frequent in practice[15] must be documented completely for the sake of transparency in the research process (cf. Greckhamer et al., 2018, p.9). Currently, only the R packages “QCA‘” (Duşa, 2020) and “CNA” (Ambuehl et al., 2014) cover all possible parsimonious solutions (cf. Thiem, 2014b, p. 505).
As mentioned before, Ragin's original approach on the one hand disencourages the inclusion of theoretically significant configurations which do not simplify the solution and on the other hand produces a parsimonious solution whose validity is doubtful. Therefore, counterfactuals should be excluded from the analysis process at an early stage and at least one Enhanced Standard Analysis, better still a Theory-Guided Enhanced Standard Analysis should be preferred. A retrospective consideration, which untenable assumptions may have been included, is possible with almost all available software solutions. Since in such a case a re-analysis has to be carried out under exclusion of those assumptions (cf. Kahwati and Kane, 2019, p. 150), it would be reasonable and economic to exclude already known, untenable assumptions in advance.
Since all possible solutions have the same validity and relevance, it is in principle open which of the solutions is presented at the end. However, it is part of current best practice proposals that all three forms of solutions, conservative, intermediate and parsimonious, are always presented (cf. Schneider and Wagemann, 2009, p. 406). Together with other important information about

[15]Thiem, 2014b replicates various studies in its article and reveals a range of 2 to 66 possible models in more than half of them.

logical remainders, recipients can thus weigh up the validity of the assumptions made that led to the solutions. There is, however, freedom in the weighting of a solution path in its theoretical interpretation. It should depend on the research question and the scientific interest. For exhaustive analyses whose goal is not to make predictions but to explain the empirical findings, conservative solutions are more appropriate. By contrast, a parsimonious solution is more appropriate in the search for the "minimum requirements" for an outcome.

Excursus: Causality

Closely related to the solutions ultimately found is also the question of the causal interpretability of a Qualitative Comparative Analysis. This is a frequent point of contention and criticism within the methodological discussion (cf. Mahoney, 2004; Baumgartner, 2014; Baumgartner and Thiem, 2017; Jordan et al., 2011; Thiem and Baumgartner, 2015; Seawright, 2014).

This is probably mainly due to the fact that QCA is not based on a correlative understanding of cause and effect, but on necessary and sufficient conditions. Correlative causality assumes that higher or lower values in one variable will probably produce higher or lower values in another variable. Whereas, for example, necessary causality implies that the occurrence of a certain value range of an outcome always or often requires the presence of a certain value range of a condition, independent of the values of the other variable (cf. Mahoney, 2004, p. 18). Rubinson and others refer to this as "focus[...] on the causes of effect, rather than the effects of causes" (Rubinson et al., 2019, p. 2).

Likewise, QCA is not based on an experimental design, which some authors consider the strongest way to derive causality (cf. Kahwati and Kane, 2019, p. 198). In this light, the possibilities of causal inference of a QCA are limited. The solutions are not absolute (cf. Jordan et al., 2011, p. 1168) and do not per se explain the underlying mechanisms that produce the outcome (cf. ibid.). Seawright points out that any assumptions about causal inference based on a single case observation imply that context is the same as cause. Both in regression and in the QCA pattern of correlations would be interpreted as causal reasons (cf. Seawright, 2005, p. 23).

Ragin expresses himself in this respect, as the assertion of causality must be made on a solid basis of theoretical and substantial knowledge, because "[c]ausal connections are not inherent in data" (cf. Ragin, 2008, p. 54f.; see also: Rubinson et al., 2019, p. 2).

Thus, it becomes apparent that the use of the term "causal inference" should only be used very cautiously in connection with QCA results, or perhaps should be avoided altogether (cf. Kahwati and Kane, 2019, p. 12).

Thiem and Baumgartner also deal with the topic of causality in QCA on a methodological level and state:

> *The crucial mechanism of QCA that turn necessary and sufficient conditions into causally interpretable necessary and sufficient conditions is the elimination of redundancies (Thiem and Baumgartner, 2015, S. 3).*

Baumgartner names so-called **Boolean difference-maker**, i.e. conditions which are indispensable and non-redundant (cf. Baumgartner, 2014, p. 4). For example, if condition A is sufficient for Y, then AX, where X is any other condition, is also sufficient. X, however, has no influence on Y and can therefore be removed from the solution without changing the validity of the statement about the

Table 3.28: Calculation solution consistency

Case	SMV AB+Ac	Outcome Y	min(AB+Ac, Y)
1	0,4	0,6	0,4
2	0,3	0,9	0,3
3	0,1	0,8	0,1
4	0,7	0,8	0,7
5	0,6	0,5	0,5
6	0,4	0,6	0,4

relationship to the outcome. To be part of a necessary or sufficient condition does not necessarily mean to be part of the cause (cf. ibid., p. 5). For this reason, Baumgartner concludes, intermediate and conservative solutions must never be causally interpreted, since they consciously allow for redundancies. These solutions can serve to describe and better understand and communicate the data (cf. ibid., p.2, footnote).

Only Boolean difference-maker in data that meet the necessary standards can be reliably assumed to be causes (cf. Baumgartner, 2014, p. 7). Possible error sources are confounding factors, incorrect calibration, measurement errors, fragmented data, etc. Since the problems can never be completely excluded with certainty, there is always an **inductive risk** (Baumgartner, 2014, p. 7). So causal inferences can always be faulty.

For the reasons given above, this paper will therefore also refrain from interpreting results as "causal reasons" in the sense of classical inferential statistics.

3.3.6 Goodness-of-fit and robustness tests

In order to determine the quality of a QCA solution, a number of criteria have been developed since the development of the method, which check different aspects of a solution formula with regard to their plausibility.

Consistency

The consistency measure and its calculation was already introduced before. On the one hand to determine which rows of the truth table can be assumed to be subsets of the outcome and are therefore primitive expressions of the overall solution (raw consistency) and on the other hand as a measure for the validity of a necessary condition.

The **solution consistency** is another way to get a consistency value for a final result, and thus to get a statement about how persistent the assumption of a subset/superset relationship between solution and outcome is. For this purpose, analogous to the calculation of a raw consistency, the minimum SMV of solution term and outcome of each case is summed up and divided by the sum of the SMV of the solution term. The only difference to the calculation in table 3.25 is that the affiliation values not only to a row but to several configurations connected by operators have to be calculated beforehand. For the example in table 3.28 this would result in a consistency value of:

$$Solution\,consistency_{AB+Ac} = \frac{0,4+0,3+0,1+0,7+0,5+0,4}{0,4+0,3+0,1+0,7+0,6+0,4} = \frac{2,4}{2,5} = 0,96 \qquad (3.15)$$

Since only in case 5 the solution term membership value exceeds that of the outcome, there is

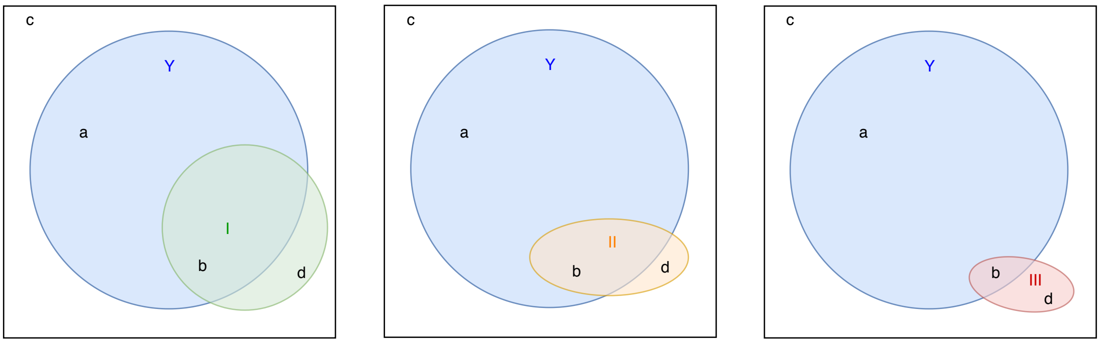


Figure 3.12: Different degrees of coverage

an almost perfect consistency for the statement $AB + Ac \rightarrow Y$. As for the previous consistencies, values starting at about 0.75/0.8 can be considered "good" (see section 3.3.4).

Coverage

Although all solutions are equivalent in terms of their validity (cf. Ragin, 2008, p. 54), the principle of equifinality makes it necessary to know how much of the empirical evidence is covered by the solution. Looking at solutions I, II and III in the Venn diagrams in Figure 3.12, all three are subsets of the outcome Y. However, solution I with its consistent area b covers a significantly larger part of Y than the area b of solution III. Solution I thus covers more empirical cases than the other two solutions and is therefore empirically more relevant (cf. Kahwati and Kane, 2019, p. 141, Ragin, 2008, p. 55). Higher values identify sufficient configurations, which are present in many cases of the outcome set (cf. Kahwati and Kane, 2019, p. 141), low values, on the other hand, indicate that a large part of the "story that may lie within the data" (Miller, 2017, p. 8) remains hidden. In the most extreme case, several solution paths of a formula are only valid for one single case each, so they have virtually no significance when trying to reduce the complexity found in the data.
To formalize this question of **empirical relevance**, Ragin introduces the measure of **coverage** (cf. Ragin, 2006, p. 9). The corresponding formulas for necessary and sufficient conditions are mirror images of the corresponding formulas of consistency:

$$Coverage_{sufficient\,conditions(X_i \leq Y_i)} = \frac{\sum_{i=1}^{I} min(X_i; Y_i)}{\sum Y_i} \tag{3.16}$$

$$Coverage_{necessary\,conditions(X_i \geq Y_i)} = \frac{\sum_{i=1}^{I} min(X_i; Y_i)}{\sum X_i} \tag{3.17}$$

Coverage is thus calculated from the minimum SMVs of solution or outcome of all cases, divided by the sum of the SMVs of Y (sufficient conditions) or X (necessary conditions), corresponding to the assumed direction of the subset relationship. If the areas a to d in figure 3.12 are assigned numerical values, the resulting four-field tables in figure 3.13 can be used to easily calculate the coverage of a sufficient condition for a csQCA. For this, only the consistent proportions (b) must be divided by

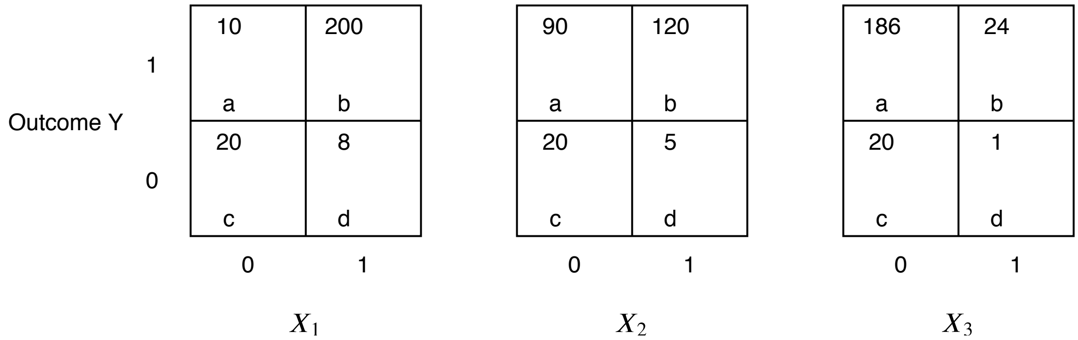


Figure 3.13: Crosstabulation coverage after Schneider and Wagemann, 2012, S. 131

the number of total cases in which Y is present (a+b):

$$Coverage_{X_1} = \frac{200}{210} = 0,95$$

$$Coverage_{X_2} = \frac{120}{210} = 0,57$$

$$Coverage_{X_3} = \frac{24}{210} = 0,11$$

It turns out that for X_3 there is a large number of cases that are part of the outcome, but not of the X_3 solution. It is considered to have little relevance compared to the other two and conclusions drawn on its basis must be considered with caution. Although they are compatible with the available data, they have only limited validity.

If several or even all solution terms of a QCA have only small degrees of coverage, this indicates that, due to equifinality and causal complexity, there are probably other conditions that are better able to capture the relevant outcome (cf. Kahwati and Kane, 2019, pp. 141f.). An iterative check of the selected conditions, calibration procedures, case selection, etc. would therefore be appropriate.

The coverage can be calculated not only for individual conditions (as in the XY plots figure 3.8 and 3.9), but also for a complete solution, analogous to consistency. The so-called **solution coverage** is calculated identically to the solution consistency, except that the summed SMVs of the outcome serve as divisors. This means for table 3.28:

$$Solution\,consistency_{AB+Ac} = \frac{0,4+0,3+0,1+0,7+0,5+0,4}{0,6+0,9+0,8+0,8+0,5+0,6} = \frac{2,4}{4,2} = 0,57 \tag{3.18}$$

In addition, two further coverage values are to be introduced, which can provide information about the quality of a solution: The **raw coverage** and the **unique coverage** (cf. Ragin, 2008, pp. 66f.). The raw coverage describes how much a path of a solution contributes to the explanation of the outcome if it is considered alone. The unique coverage, on the other hand, covers the area of the solution path that covers the outcome alone and without redundancy. For clarification, this is explained in figure 3.14: In contrast to I, solution II and III have an overlap (R) on the left side. The raw coverage now includes the entire area covered by the solutions within Y. This means II+R or III+R. Regardless of the redundancy, this is the explanatory power of both solution terms. The higher the value, the more important is a path within an overall solution.

If II and III were now largely congruent (shown on the right-hand side of the figure), the consider-

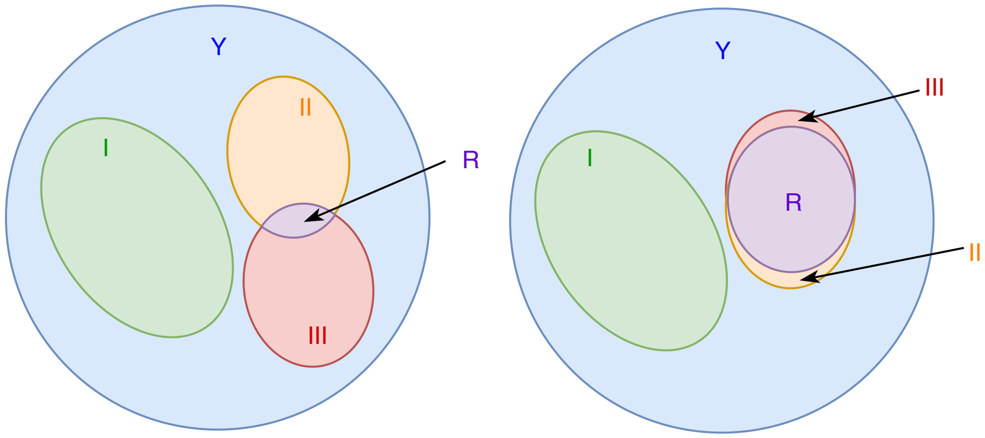


Figure 3.14: Example: High and low degree of unique coverage

ation of the raw coverage would lead to the attribution of too much importance to both solutions individually. The coverage would be relatively high, but the information would be lost that both cover the same cases of the outcome to a large extent. For this reason, it is helpful to calculate the unique coverage of a solution term. It is calculated by subtracting all other solution terms from the solution coverage. In the example: Solution coverage - raw coverages (I + II) = unique coverage III or solution coverage - raw coverages (I + III) = unique coverage II. The redundant area R is therefore excluded (cf. Schneider and Wagemann, 2012, p. 134). This allows a more substantial statement to be made about the empirical relevance of individual subareas of a solution. Low values in the unique coverage may indicate that redundant prime implicants exist in the solutions or that the conditions are interchangeable (cf. Rubinson et al., 2019, p. 5) and thus speak against a causal interpretability (see above).

The calculation of the coverage measures only makes sense for solutions that are already identified as consistent (cf. Schneider and Wagemann, 2012, p. 148). Since software solutions usually output all common quality measures anyway, one should therefore first look at the consistency values. Only for solutions for which a validity can be assumed, it is logically necessary to check the empirical importance of this validity. In contrast to consistency, there is no “too little” coverage. Solutions with low coverage may cover only a small part of the population of the outcome, but they can be theoretically relevant and interesting special cases (cf. Rubinson et al., 2019, p. 5f.). To exclude them, similar to a cut-off value, would logically make no sense, since they are nevertheless valid ways to develop the outcome.

Table 3.29: Overview: Formulas for consistency and coverage

	Sufficient	Necessary
Consistency	$\frac{\sum_{i=1}^{I} min(X_i;Y_i)}{\sum X_i}$	$\frac{\sum_{i=1}^{I} min(X_i;Y_i)}{\sum Y_i}$
Coverage	$\frac{\sum_{i=1}^{I} min(X_i;Y_i)}{\sum Y_i}$	$\frac{\sum_{i=1}^{I} min(X_i;Y_i)}{\sum X_i}$

The calculation formulas for consistency and coverage are, as already mentioned in some places, mirror images of each other. The formula for calculating the consistency of sufficient conditions is identical to the formula for the coverage of necessary conditions and the formula for the consistency of necessary conditions is identical to the formula for coverage of sufficient conditions (see table 3.29). This also means that the values are related to each other: higher consistency values usually mean a lower level of coverage (cf. Schneider and Wagemann, 2012, p. 149). This is related to the fact that the connection of several conditions with sufficient conditions leads, for example, to the fact that it becomes more and more difficult for a case to belong to this set. At the same time, it also means that it becomes smaller and more specific, thus increasing the probability that it is a consistent subset of the outcome. However, because of this more difficult possibility of belonging to a set, there are also fewer cases within the outcome that (could) fall into this configuration. This leads to a decrease in coverage. In practice, therefore, a compromise must be found between high consistencies and large coverage. The fact that both values are strongly present is only possible in the empirically unlikely case that all cases in the population are within a very compressed range of the outcomes.

Triviality

Necessary conditions are often exposed to the problem of triviality, which limits their interpretability. If, for example, one examines the question of whether people with dementia in a nursing home with decubital ulcers are medically well treated, the presence of nursing staff (A) is a necessary condition for the outcome (Y_1). Without nurses, care cannot take place at all. So this condition is so fundamental that its meaning is trivial. Nursing staff are also available in all other institutions (A), in which no good medical care is provided (y_1). Logically, A is necessary for Y_1, but it is just as necessary for proper documentation, administration of medication, contracture prophylaxis, etc. Y_1 thus covers only a very small part of X. In another case it is investigated whether the existence of a legally regulated quota of registered nurses in Baden-Württemberg (B) is necessary in order to explain quotas of registered nurses in homes of at least 50% Y_2. Since such a quota of 50% is given there and only a few exceptions are formulated for an underrun, there are hardly any cases in which **less** than half of the nursing staff are registered nurses (y_2). Y is therefore approximately equivalent to B. This can be illustrated using a Venn diagram (Figure 3.15).

Two forms of triviality can therefore be identified: One in which there is no variation in the condition and one in which there is no variation in the outcome (cf. Caramani, 2009, pp. 62f.,Braumoeller and Goertz, 2000, pp. 854). They differ in the relation of size of outcome to condition. With type 1,

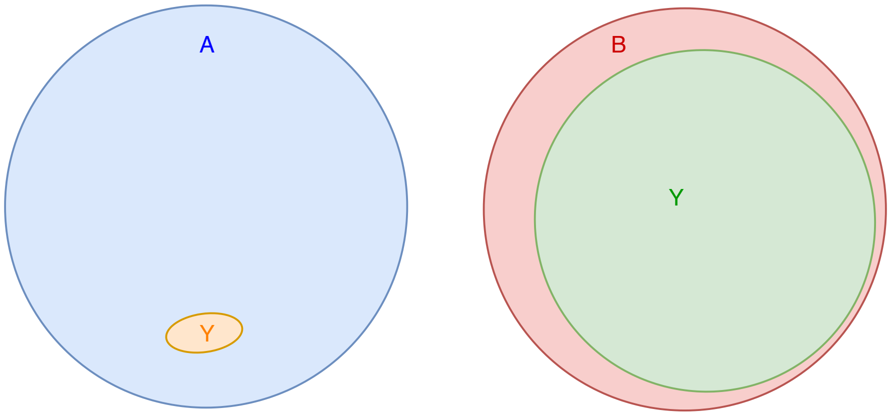


Figure 3.15: Forms of trivially necessary conditions

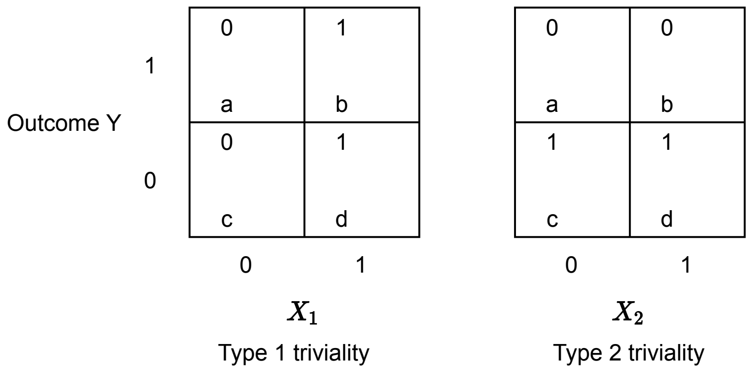


Figure 3.16: Crosstabulation triviality

the necessary condition is always present when the outcome occurs, but it is also present in almost all cases where the outcome does not occur. With type 2, on the other hand, the condition is always present when Y occurs, but there are hardly any cases in which the outcome is not present.

In the previous considerations of necessary conditions, attention was only paid to cases in which the condition occurs. They are decisive for the decision whether X is necessary or whether cases argue against this assumption. For this purpose, the four-field table 3.7 contains cells with allowed and not allowed cases. Irrelevant so far were instances of the values $X = 0, Y = 0$ and $X = 1, Y = 0$. They do not contradict the consistency, but still have a logical meaning for the interpretation (cf. Schneider and Wagemann, 2007, p. 98). X_1 is a necessary condition because it is always present when Y also occurs (cell b). Due to the cases in cell d and the resulting invariance of the condition, X_1 becomes trivial. Likewise, X_2 is a necessary condition, since Y never occurs in the absence of X_2 (cell c or a). Due to the occupation with cases in cell d and the resulting invariance of the outcome, X_2 now becomes trivial (cf. Caramani, 2009, p. 62).

The formula of coverage, introduced in the previous section, serves in such cases as a measure of the triviality of a necessary condition. It recognizes, however, as Schneider and Wagemann state, only triviality of type 1, in which reference must be made to the relations of X and Y (cf. Schneider and Wagemann, 2012, p. 147). Type 2 triviality remains unrecognized, since here the relation of

occurrence and absence of the condition is decisive. This can be explained, because in cases where the affiliation to X is particularly large (approximating 1), the denominator from formula 3.17 corresponds approximately to the number of cases. The numerator, on the other hand, due to the high SMVs of X, contains virtually only values of Y. Thus the approximate result is: $\frac{\sum Y_i}{n_X}$ and this corresponds approximately to the average of Y. If Y itself now also has consistently high SMVs, as is the case with type 2 triviality, the coverage value is high without the problem of trivial, necessary conditions being recognized (cf. Schneider and Wagemann, 2012, p. 234).
For this purpose, Goertz developed a measurement value in 2003 based on his considerations on triviality, which is calculated as follows Goertz, 2003:

$$T_{nec} = \frac{1}{N} \sum \frac{1 - x_i}{1 - y_i} \tag{3.19}$$

Since for necessary conditions in fuzzy sets the SMV of $X \geq Y$, and can be at most 1, the triviality is standardized as a distance of X to 1, by the maximum degree of importance based on Y. For all X as well as for Y therefore the distance from the maximum value 1 is calculated (cf. Goertz, 2003, p. 7). A completely trivial condition would have 1 in all X values and thus the result of the formula would be 0. The further away the value is from 0, the more non-trivial the condition becomes. Goertz's formula, however, in contrast to the coverage of Ragin, has no upper maximum and is therefore more difficult to interpret than the previous values between 0 and 1. That's why Schneider and Wagemann use an example to show that it is susceptible to inconsistencies in the data (cf. Schneider and Wagemann, 2012, p. 236). They then develop the following formula for the relevance of a necessary condition (**Relevance of Necessity (RoN)**), which should combine the advantages of the formulas of Ragin and Goertz (Schneider and Wagemann, 2012, p. 144):

$$\text{RoNy} = \frac{\sum(1 - x_i)}{\sum(1 - min(x_i y_i))} \tag{3.20}$$

Hereby, through the distance to 1 suggested by Goertz, type 2 trivialities, in which X is quasi constant, can also be recognized. The formula moves exclusively between the values 0 and 1. Low values speak for triviality and high values for the relevance of the condition (cf. Schneider and Wagemann, 2012, p. 237).
In conclusion, it should be noted that triviality always remains an empirical concept. There is no change in the validity of the statements that certain conditions are necessary and that this can be proven on the basis of the data (cf. Braumoeller and Goertz, 2000, pp. 854f.). Therefore, it must also be weighed up here when a condition is **too** trivial in order to imply it into the interpretation. The value of relevance can only be an aid to this.

Proportional Reduction in Inconsistency

Schneider and Wagemann note that, in addition to the case of a very comprehensive condition X, which leads to trivial conclusions about the necessity, there are also cases where the affiliation values of X are very small. Thus, empirically, there are cases where the condition could be interpreted as sufficient for both forms of the outcome (cf. Schneider and Wagemann, 2012, pp. 237f.). Condition X is thus a subset of both Y and y (cf. Flechtner and Heinrich, 2017, p. 3, Greckhamer et al., 2018, p. 8). Section 3.3.5 already addressed incoherent assumptions about logical rudiments, where a condition is simultaneously responsible for the occurrence and absence of an outcome. Now, however, these are instances in which there is no limited empirical diversity (see figure 3.30).

Table 3.30: Simultaneous consistent subset relationship of X with Y and y (after Schneider and Wagemann, 2012, S. 238)

	Condition	Outcome	
#	X	Y	y
1	0,1	0,8	0,2
2	0,2	0,4	0,6
3	0,3	0,3	0,7
4	0,7	0,6	0,4

Case 4 with its SMV in X exceeds the qualitative anchor of 0.5; thus an empirical instance is present. The SMVs of the condition in the other cases are lower than the SMVs of the outcome in both variants. If the consistency values are calculated, $X \rightarrow Y$ has a value of 0.923 and $X \rightarrow y$ has a value of 0.769. Thus, X could be assumed to be sufficient for both types of outcome. On the basis of a published study, the two authors show that such cases also occur in practice, even if strict requirements are applied to a consistency threshold. However, a simultaneous validity for both types of outcome is logically not possible and thus the conventional consistency measure reaches its limits.

Charles Ragin developed a measure which he embedded in his “fsQCA” software, but whose calculation and interpretation he does not document in the accompanying manual. In 2011, he describes it in more detail in an email dialogue with Jerry Mendel (Mendel and Ragin, 2012), which is available as a report, and he leaves it up to Schneider and Wagemann to publish the formula in their work “Set-Theoretic Methods for the Social Sciences”. The measure was named **Proportional Reduction in Inconsistency (PRI)** in accordance with the “proportional reduction in error” (PRE) of statistical association measures (cf. Mendel and Ragin, 2012, p. 50).

$$\text{Proportional Reduction in Inconsistency (PRI)} = \frac{\sum_{i=1}^{I} min(X_i;Y_i) - \sum_{i=1}^{I} min(X_i;Y_i,y_i)}{\sum X_i - \sum_{i=1}^{I} min(X_i;Y_i,y_i)} \qquad (3.21)$$

The calculation is carried out analogously to the consistency of sufficient conditions. However, in both numerator and denominator, the union value is subtracted from the condition and outcome values (cf. Flechtner and Heinrich, 2017, p. 8). This results in lower results in the PRI score for consistency values lying close together and higher results for consistency values that lie far apart. But this is also the case if X is not qualified at all to be considered a sufficient condition (cf. Schneider and Wagemann, 2012, p. 242). Therefore, PRI must be seen as a supplement and not a substitute for the consistency measure.

Here, too, there are no fixed threshold values, above which one speaks of “bad” or “good” PRI values. In general, Ragins opinion on threshold values ist, that they should be set individually and speaks against the orientation towards convention values (cf. Mendel and Ragin, 2012, pp. 37ff.). Greckhamer and others on the other hand speak of “significant inconsistency” (Greckhamer et al., 2018, p. 8), should the value fall below 0.5.

Robustness

As has emerged from the previous explanations of Qualitative Comparative Analysis, many processes are dependent on “qualitative judgments” (Hofstad, 2019, p. 1) of the user. Therefore, at the end of a QCA not only selective criteria, like those presented above, should be checked, but also a general robustness of the results. This is

> *[...] the degree to which the solutions are sensitive to (small) changes in the discriminatory choiches made by researchers in various stages of the process of systemativ complexity reduction [...] (Skaaning, 2011, S. 392).*

This test must be in accordance with the basics of the method and should not be an imitation of classical statistical tests for goodness of fit (cf. Greckhamer et al., 2018, p. 9). Although there is still no agreement on which tests should be used in a meaningful way for a typical QCA, the following methods are often used (cf. Schneider et al., 2019, p. 5f.):

- Change of the sample or the configuration model
- Change of the consistency thresholds
- Changing the calibration

Probably the first and most frequently cited study on the robustness of QCA results is “Assessing the Robustness of Crisp-set and Fuzzy-set QCA Results” by Svend-Erik Skaaning from 2011 (Skaaning, 2011). He reanalyses three studies, systematically changes the parameters mentioned and examines the resulting solutions. In doing so, he is primarily concerned with potential differences between crisp set and fuzzy set QCA. However, the results do not allow any categorical conclusions to be drawn about an advantage of either of the two forms. In one study the csQCA results proved to be more robust, in the other two the fsQCA solutions. In his work, however, he brings together the tests that have been used in fragmented form to date.

Usually such solutions are considered “robust” which, after variation of the manipulated variables, are the same solution paths or are subsets or supersets of the original solution (cf. Kahwati and Kane, 2019, p. 155) and which show only minor changes with respect to their consistency and coverage values. A substantial, i.e. qualitative, change of the solution approaches should not occur (cf. Greckhamer et al., 2018, p. 9).

As explained in the corresponding section, samples and populations are not fixed in the QCA, but can be changed in their composition. In the case of a robustness test, for example, cases that were previously borderline with respect to their relation to the sample can be excluded or included. This results in necessary changes in the composition of the truth table. New cases can lead to rows exceeding the consistency threshold and thus be considered sufficient for the outcome or can reduce empirically limited diversity by filling empty rows with empirical instances. Similarly, removal can lead to the resolving of contradictions and the elimination of inconsistencies (cf. Kahwati and Kane, 2019, p. 155). According to the same principle, conditions can also be replaced or complemented. This step, in comparison to the others, requires a sound approach and is usually only to be used if there are reasons for the changes of these parameters.

By changing the consistency threshold, the "strictness" applied for inclusion in the analysis process can be controlled. If many conditions or rows of the truth table are only just below or above the threshold value, even small adjustments lead to substantial changes in the solution. They are therefore less stable. The consideration of reducing the necessary consistency must always be weighed against the resulting problem that by this step less consistent statements can also be included in the solution (cf. Skaaning, 2011, p. 402). A middle course must be found between exclusively perfect consistency and assumptions that are barely tenable. This is because, in contrast to other robustness tests, the resulting changes can have a significant impact (cf. Schneider and Wagemann, 2012, p. 291). It is recommended to test at least two different threshold values against each other and to check whether the parameters of fit change (cf. ibid., p. 292).

It is also recommended to check the calibration. Here too, the selected anchor values should be changed and the influence on the result should be assessed. For this purpose, the selection of at least one strict and one soft parameter is recommended (cf. Maggetti and Levi-Faur, 2013, p. 203). Since the choice of the crossover point is the most important decision of the calibration process (cf. Schneider and Wagemann, 2012, p. 287), its robustness check is extremely important (cf. Kahwati and Kane, 2019, p. 155). At it, qualitative differences within the conditions are constituted. If the SMVs of cases fall close to this point, a change can also bring a substantial change in the qualitative interpretation of these cases.

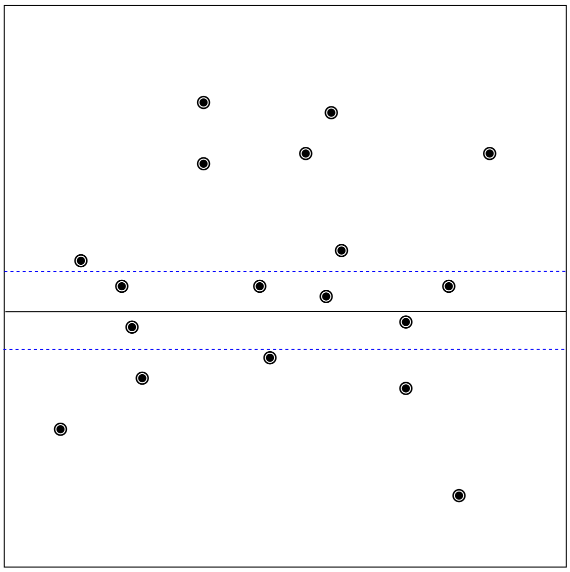


Figure 3.17: Example: Change of calibration threshold

Figure 3.17 schematically illustrates how a displacement of the original crossover point (black line) results in more or less cases exceeding the anchor value (blue dotted lines). To what extent a different calibration ultimately influences the solutions is impossible to predict for equifinal solution terms (cf. Schneider and Wagemann, 2012, p. 288).

At the time of writing this thesis, Tore Hofstad presented a COMPASSS Working Paper in which he introduced a new approach to testing calibration robustness (Hofstad, 2019). By means of a **robustness range** corridors for the three qualitative anchors: complete membership, crossover point and complete non-membership are to be determined, within which the calibration can be changed without changing the solution or the cases covered (cf. Hofstad, 2019, p. 2). For this purpose, in the absence of an automated process, the threshold values of each condition are moved

up and down. This is done until the original solution changes. Wide corridors speak for robust solutions. If the possibilities for change are small, the QCA results must be considered unstable (cf. ibid., p.3).
Hofstad sees the application mainly in intermediate and large-n fields of application, since here case knowledge is only slightly developed and narrow corridors are difficult to justify by means of substantial knowledge.
Cooper and Glaesser (Cooper and Glaesser, 2015) also test further robustness tests for large-n QCA samples. They refer to a very large population of 6666 cases (cf. ibid., p. 2). Since, as expected, in such cases the elimination of a single case has no effect on the parameters or the solutions, they make two suggestions for alternative tests: On the one hand, they check the susceptibility to measurement errors. To do this, they generate an "erroneous" data set from the original data by adding a random error variable to a single variable of the configuration model. On the other hand, a bootstrapping method to test the robustness of the original solution using this random data set. However, this method has not yet found a wider reception among QCA users. Furthermore, no software solution offers the possibility to apply it. This, and the fact that such large samples are still very rare in QCA, probably hinders further dissemination. However, the points mentioned by Cooper and Glaesser are understandably very relevant in the large-n field. It should be noted, however, that the authors in their paper only allowed a single condition to vary. Consequently, the susceptibility to measurement errors would have to be examined across the entire configuration model. Without an automated solution, this is difficult for individual users without comprehensive methodological, theoretical and technical knowledge.
Emmenegger et al. (Emmenegger et al., 2014) make another proposal for robustness testing for large samples. The random, proportionate removal of cases (cf. ibid., p. 18). Thereby it can be checked how much of the solution paths are based on individual groups of cases. The authors eliminate 10% of the observations from the sample and perform a new analysis. Furthermore, large data sets offer more possibilities to vary the frequency threshold for rows in the truth table. For several thousand cases, the presence of a single or small number of cases in a row may be due to random errors. Therefore a higher threshold should be chosen anyway. Emmenegger and others experiment with frequencies between 5 and 50 and check the robustness by means of possible changes in the solutions (cf. ibid., p. 22). The authors are of the opinion that the influence of random errors in large samples can be mitigated by these two procedures.

3.3.7 Presentation und interpretation

Over the years, many ways have been developed to present the results of a Qualitative Comparative Analysis. These include both graphical and tabular or written forms. The aim of the presentation should be, firstly, to present the relationship between the conditions in a clear manner. Secondly to make descriptive or causal factors clear for specific cases or groups of cases, and thirdly to document the quality of adaptation to the empirical data (cf. Schneider and Grofman, 2006, p. 8). In order to achieve this, it is necessary to represent the analytical objects that are produced on the path of a QCA: Calibrated data, truth table and sufficient or necessary relations with the outcome (cf. Rubinson et al., 2019, p. 2). A recent work by Rubinson presents and discusses the currently, more or less frequently, used forms of presentation (Rubinson et al., 2019).
For the presentation of solutions in this thesis a Concov-Table (Consistency Coverage Table) shall

be used. It contains all necessary and sufficient conditions as well as the corresponding quality measures in a clearly arranged way and thus fulfills all common requirements for a tabular presentation (cf. Rubinson et al., 2019, p. 18, Greckhamer et al., 2018, p. 10, Rihoux and Meur, 2009, p. 65, Schneider and Wagemann, 2012, p. 280).
The Venn diagram has long been considered the most common form of graphical display in Qualitative Comparative Analysis. It is ideal for providing comprehensible access even to people who are not familiar with the subject or method, as it is intuitively accessible. For more elaborate considerations, however, the author agrees with Rubinson's opinion:

[I]t is difficult to decode and interpret Venn diagramms of more than a handfull of sets. They also offer low information densitiy: they take up a lot of space and convey relatively little. (Rubinson et al., 2019, S. 14).

Alternatively, two other, in the opinion of the author, more suitable forms of presentation are presented.
First the **configuration chart** or, named after its developer Peer C. Fiss, "Fiss Chart". In this chart, several solutions are presented next to each other in a particularly clear manner, and the role and influence of different conditions are made clear. The columns show the configurations, the rows the conditions. In the cells different symbols are used to display presence (●) and absence (⊗). In addition, Fiss distinguishes between "core conditions" and "contributory conditions" (cf. Fiss, 2011, p. 36), whereby the former are represented by large, the latter by small symbols. So core conditions are conditions that are present in the most pasimonious solution, i.e. they are a basic requirement for the solution and cannot be minimized further. Whereas contributory conditions are conditions that originate from higher-level solutions, intermediate or conservative, and thus are in a subset relationship to core conditions. The corresponding quality measures for each partial solution as well as for the entire solution path are given below the symbols. A graphically very good and clear possibility of the representation are **star charts**. In these charts the conditions are arranged in a circle around a center. Present and absent conditions are symbolized as in the case of the Fiss Chart. Conditions that are not relevant for the solution are not given a symbol. By means of connecting lines from the centre, the different solutions are shown: Solid lines for conditions of the most parsimonious solution, dashed lines for contributory conditions (see figure 3.19[16])(cf. Rubinson et al., 2019, p. 11f.). Star charts can thus be combined very easily with the configuration charts presented above. However, a separate star is required for each configuration and quality measures are not included. Therefore they should only be used as an illustration of a tabular presentation. Due to a lack of conventions up to now, it is up to each user to decide which form of visualization he or she chooses. The decisive factor is rather the clarity and the question whether all necessary information regarding the solutions and the decisions made during the analysis process are presented transparently. It is advisable to choose different forms of presentation next to each other (cf. Schneider and Wagemann, 2012, p. 280).

Ultimately, however, not only a presentation of the solution is necessary, but also its interpretation. For only by feeding back the solutions to the cases could inference be established, according to Schneider et al. (cf. Schneider et al., 2019, p. 6). For this purpose, analyses can be performed

[16]The author thanks Claude Rubinson for the exchange regarding the presentation of QCA results and for providing his graphics from the publication

Table 5: Configurations for Achieving Very High Performance

	Solution		
	1a	**1b**	**2**
Structure			
Large Size	•	⊗	⊗
Formalization	•	•	⨂
Centralization	⊗	•	•
Complexity	●	●	⊗
Strategy			
Differentiation	•	•	●
Low Cost	●	●	•
Environment			
Rate of Change	⨂	⨂	⊗
Uncertainty	⊗	⊗	●
Consistency	0,83	0,83	0,84
Raw Coverage	0,17	0,22	0,17
Unique Coverage	0,03	0,04	0,03
Overall Solution Consistency		**0,81**	
Overall Solution Coverage		**0,27**	

Figure 3.18: Configuration chart after Fiss (2011), S.39

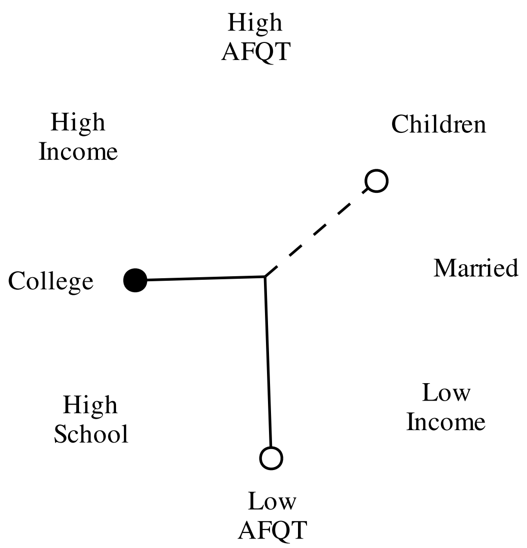


Figure 3.19: Presentation of a configuration as star chart (from Rubinson et al., 2019)

within the cases or across cases (within and cross-case analyses). **Typical cases** can be consulted first. These are those that support the assumption of a sufficient condition, i.e. the SMV of the outcome set is greater than that of the solution set (cf. Kahwati and Kane, 2019, pp.169f.). They may be the easiest way to understand how a causal mechanism works. **Unique cases** are also typical, but with the peculiarity that they are covered by only one solution path (cf. ibid.). Through them, previously unrecognized explanations of a phenomenon may be discovered and new theories may be established.

Another approach is to include **deviating cases** in the interpretation. Cases that either have a share in the solution **or** of the outcome. The former reduce the coverage of a solution. While they have the necessary characteristics to be considered sufficient, they are not part of the outcome. By comparing them with typical cases, conditions can be identified which have not been included in the analysis so far, but which make a decisive contribution.

In the second case, cases show the outcome without having the corresponding sufficient conditions. Here too, conclusions can be drawn as to which factors are still missing in the analysis. The easiest way to do this is to use **irrelevant cases**. They do not belong to either of the two sets, but can serve as a comparison if they are in the same line of the truth table. By contrasting them, conditions can be identified which are decisive for the difference between these two types (cf. Kahwati and Kane, 2019, p. 171).

In general, it should be noted that in the literature interpretation is only marginally, if at all, dealt with. It often remains only with the demand to go “back to the cases”.

3.4 Special forms of QCA

In addition to the differentiation into fuzzy-set QCA and crisp-set QCA, as a special case of fsQCA, two further concepts have been and are currently being discussed which are to be incorporated into QCA. These are on the one hand an alternative approach to fsQCA to avoid strict dichotomies, and on the other hand the introduction of the factor “time”. These two approaches sprouted at about the same time, from about 2004/2005, and have so far (status 2019) been treated rather marginally. In principle, their application is possible, but they are rarely used even in QCA-affine circles. Therefore, both approaches are presented here only sketchily and not in detail.

3.4.1 multi-value QCA

Lasse Conqvist published two COMPASS Working Papers in 2004 and 2005, in which he wanted to break up the restrictive concept of dichotomization in the csQCA. In 2009 he published an extended description of the procedure in the anthology by Rihoux and Ragin (Cronqvist and Berg-Schlosser, 2009). Cronqvist’s approach is also a “generalization of csQCA” (cf. Cronqvist and Berg-Schlosser, 2009, p. 70), but does not go as far as Ragin did in 2000 with the implementation of fuzzy logic. While the latter results in a complete resolution of the dichotomies and the parallel partial membership of all sets, the first approach makes it possible to specifically capture and analyze polytomic conditions. The author thus aims to depict concepts that cannot be dichotomized explicitly or implicitly, such as geographical regions (Europe, Asia, America...) or religions (Protestant, Catholic, Jewish...). All this could also be described by the conventional QCA methods by creating a dichotomous condition for each characteristic (Protestant: Yes (1)/No (0), Catholic (1)/No (0), Jewish (1)/No (0)). However, this inevitably leads to a much larger number of conditions compared to a constant number of cases and provides more logical remainders. The related problems have already been discussed.

Instead, Conqvist developed the approach of **multi-value QCA (mvQCA)**, which is analogous to Ragin's QCA, except with regard to notation and minimization (cf. Cronqvist and Berg-Schlosser, 2009, p. 72).

Since in an mvQCA there are several qualitative values within a condition, the previous notation of presence or absence must be changed. Instead of upper and lower case letters or marking with a tilde, the notation is written in the form of: *condition*{*value*}. Therefore, you first have to define which values the conditions have, for example for the condition "Region": Europe = 0, Asia = 1, America = 2... Germany would thus have the mvQCA value of Region{0}, USA the value Region{2} (cf. Cronqvist, 2004, p. 4). Alternatively, indices can also be used: Region_0, Region_2 (cf. Cronqvist and Berg-Schlosser, 2009, p. 73).

In order to define the characteristics of the conditions, in contrast to the csQCA, not a single threshold value is chosen, but several. For example, in his anthology entry, Cronqvist applies his method to a crisp-set analysis of Lipset, which dichotomized the gross national income per inhabitant. He changes the calibration and selects two thresholds to divide the condition in three (cf. ibid., p.78f.). All other, content-related prerequisites for the calibration do not differ in his QCA form.

When minimizing, he generalizes and defines the previously presented rule:

> *If all n multi-value expressions ($c_0\Phi$,...,$c_{n-1}\Phi$) differ only in the causal condition C and all n possible values of C produce the same outcome, then the causal condition C that distinguisches these n expressions can be considered irrelevant and can be removed to create a simpler, combined expression Φ"'*
> *(Cronqvist and Berg-Schlosser, 2009, S. 75).*

Considering the example: $A_0B_0+A_0B_1+A_0B_2 \rightarrow Y$ with a condition B with three values. Condition A is the same for all three sufficient condition paths, only in condition B they differ. Since in this case B exists in all possible forms, it can be assumed that its existence has no influence and can therefore be removed, leaving $A_0 \rightarrow Y$ as a parsimonious solution. This already shows a problem of the mvQCA: For minimization, more and more cases are needed to perform minimization as the number of conditions increases. This makes the minimization process significantly more complex than with crisp-set and fuzzy-set QCA, which ultimately often leaves more complex solutions that are harder to interpret.

The logically possible combinations of an mvQCA truth table are calculated as $k = \prod_{i=0}^{n} v_i$ (cf. Cronqvist and Berg-Schlosser, 2009, p. 75), which means that the number of expressions of all conditions are multiplied. For four conditions, where one is dichotomous, two are triples and one is a quadruple, this means $2*3*3*4 = 72$ rows in the truth table. For a conventional QCA, this would be only $2^4 = 16$ rows. The probability to fill all rows with empirical cases decreases even faster under polytomic conditions than with conventional QCA. This is accompanied by a greater risk of incorporating unsustainable assumptions into the analysis (cf. Kahwati and Kane, 2019, p. 187). Another disadvantage of mvQCA is that only dichotomous outcomes can be used. Here, depending on the investigation, the fsQCA offers greater possibilities.

In general, it can be said that the multi-value QCA copes well with a weakness of conventional methods. Not all concepts are implicitly dichotomizable and there may be advantages if polytome expressions can be detected within a condition. However, in the opinion of the author, the resulting consequential problems are blatant and need to be carefully weighed up against the advantages before applying this method. This coincides with the fact that there are only a few publications to date that use the mvQCA and that the literature is also very weak (cf. Kahwati and Kane, 2019, p. 188).

3.4.2 Involving time in QCA

Another approach to extend the possibilities of the QCA are attempts to include a time aspect in the analysis. The order in which conditions are present can be decisive for the occurrence or absence of an outcome. Schneider and Wagemann refer to this as the "temporal order of events" (Schneider and Wagemann, 2012, p. 264). In purely methodological terms, $A * B \rightarrow Y$ and $B * A \rightarrow Y$ are equivalent. Both conditions must be present to be sufficient for the outcome. In practical terms, however, the timing may be relevant: Adequate wound care (Y) includes, for example, cleaning the wound (A) and applying an antibiotic ointment (B). However, if condition B is first fulfilled, A is not a logical order to achieve Y. If one uses "/" as operator for THEN, to order the conditions, the following would apply: $A/B \rightarrow Y$ but $B/A \nrightarrow Y$.
Relationships between conditions can also lead to their temporal arrangement being relevant. If wound care (Y) were to consist of the conditions "removal of the old wound dressing" (A) and "application of a fresh wound dressing" (B), then here too A would first have to be present to enable B to produce B, in order to ultimately produce the outcome Y. Whereby A is a mandatory requirement for B and thus for Y: $A \rightarrow B \rightarrow Y$. This is a causal sequence of events (cf. Schneider and Wagemann, 2012, p. 264). The conventional QCA is not able to differentiate whether a sequence of conditions must be met and is, so to speak, "time blind".
In contrast to the mvQCA, there is a whole range of different approaches to solve this problem. Schneider and Wagemann cite four "informal" ways of incorporating the time aspect (cf. Schneider and Wagemann, 2012, pp. 265f.). They are all based on the classical form of the QCA.
First of all, different QCAs can simply be performed for different points in time. The characteristics of the conditions are surveyed/measured at different times and a separate truth table is created and analyzed for each data set. In extreme cases, this procedure produces the same solutions each time, which would mean that time has no influence on the result [17]. If the solutions differ, it can be assumed that this difference contains the time-relevant, analytical component (cf. Schneider and Wagemann, 2012, p. 265).
In another approach, data are also collected at different points in time, but are plotted in a single truth table. It is then crucial that it is not minimized (cf. Kahwati and Kane, 2019, p. 190), but that the user considers whether and to what extent cases move over time between the rows of the table.
As a third option, averages between the raw values of the points in time at which data was collected are calculated. From this, new conditions and outcomes are then constructed, calibrated and analysed (cf. Schneider and Wagemann, 2012, p. 266, Kahwati and Kane, 2019, p. 191).
In the last proposal the differences in conditions and outcome over time are calculated and these differences are then calibrated. Thus, percentage deviations from the time values can be used as a starting point for the assignment of SMVs (cf. Schneider and Wagemann, 2012, p. 266).
Apart from these four suggestions, Ragin already points out in his first publication in 1987 that

[17] In case one assumes that no measurement errors, transmission errors etc. have occurred

his examples are relatively static and that this contradicts his claim of a comparative, historical analysis (cf. Ragin, 1987, p. 162). He therefore suggests that one should record one's own dichotomous variables that capture the temporal aspect, for example "class mobilization preceded ethnic mobilization" (Ragin, 1987, p. 162), Yes(1) or No(0).
All these suggestions use the normal QCA methodology. In addition, however, there are a number of formalized methods that are completely or partially detached from this framework. Of these, the **temporal QCA (tQCA)**, as the oldest representative (2005), and the **Pooled Cross-Sectional Analysis**, as the most recent representative (2016), shall be briefly presented.

The temporal QCA was first presented in 2005 by Caren and Panofsky (Caren and Panofsky, 2005). They use a hyphen "-" as a new operator to indicate the temporality of conditions in the QCA. However, it immediately presents a first, major hurdle in the strategy: It multiplies the number of logically possible combinations extremely. In concrete terms, k conditions result in $k! * 2^k$ possibilities (cf. ibid., p.159).
The authors would like to limit these possibilities by considering only those cases in which conditions exist. If a condition does not occur, it is hardly possible to determine the chronological sequence. In relation to the previous example, this would mean If no antibiotic ointment is applied during wound care (b), it does not make sense to define whether this absence "occurred" before (b/A) or after (A/b) the cleansing (A). On the other hand, temporal sequences can be excluded by examining the contents. For example, there could be substantial reasons to assume that some conditions always occur at the beginning or end of a sequence. Combinations in which this is not the case could thus be excluded in advance as untenable assumptions (cf. ibid., p.159).
Consequently, the minimization of the truth table also results in differences or additions to the previous procedure. As a new rule, the THEN operator can be replaced by AND in time sequences, which differ only in the order of two conditions. If there are two ways $A-B-C-D$ and $A-C-B-D$, both are logically equivalent to the expression $A-BC-D$ (cf. ibid., p.162). In addition, conditions can be eliminated if, as in the case of the conventional QCA, they differ only in their value, but the rest of the solution is identical. In the tQCA, however, this only applies if they are located in the same temporal block, i.e. are delimited by hyphens (cf. ibid., p.163). $A-BC-D+A-Bc-D \rightarrow Y$ could therefore be minimized to $A-BD \rightarrow Y$. A sequence $A-B-C-D+A-B-C-d \rightarrow Y$, on the other hand, could not be shortened since they are separate sequences and D and d are not in a common block.
With this rule, it is now possible to set up an own truth table and simplify solutions, which can then ultimately also take into account the chronological sequence. However, the high number of possible combinations, which promotes limited empirical diversity, as well as the measures proposed to counteract this, must be critically evaluated. Although the "non-occurrence" of a condition is often not logically assignable in time, some events can be found, especially in the political science context from which the QCA originates, whose absence can be anchored as a significant factor within a timeline. The absence of military support from neighboring countries in the event of war, for example, could easily be located in time and could have consequences for diplomatic relations with the country in question.
Furthermore, there is by far not always sufficient knowledge to fundamentally exclude certain temporal sequences from conditions. The complexity of real phenomena, however, often cannot be so

clearly defined and, in addition, may require significantly more complex and extensive sequences than can be usefully processed by the tQCA (cf. Kahwati and Kane, 2019, p. 192).

As a further approach, Garcia-Castro and Ariño developed the Pooled Cross-Sectional Analysis, which works with panel data instead of, as is otherwise predominant in quantity-theoretical methods, cross-sectional data (cf. Garcia-Castro and Ariño, 2016, p. 64). The focus here is on the various possibilities of calculating consistency between and across the individual time series and thus uncovering subset and superset relationships with the outcome, i.e. sufficient and necessary conditions. The authors establish for this purpose the **Pooled Consistency**. It describes the consistency over all observations i over the collection points t and is calculated as follows:

$$\text{Pooled Consistency}(X_{it} \leq Y_{it}) = \frac{\sum_{i=1}^{N}\sum_{t=1}^{T} min(X_{it}; Y_{it})}{\sum_{i=1}^{N}\sum_{t=1}^{T} X_{it}} \tag{3.22}$$

As can be seen from the formula, it is merely an extension of the consistency formula introduced by Ragin. It reflects the consistency of the sample, "when time and individual effects are not taken into account" (Garcia-Castro and Ariño, 2016, p. 65). Garcia-Castro and Ariño use the original formula as **Between Consistency** to calculate the measure for a single point in time. Finally, they introduce the **Within Consistency**, which allows to determine consistency not across cases but across points in time:

$$\text{Within Consistency}(X_{it} \leq Y_{it}) = \frac{\sum_{t=1}^{T} min(X_{it}; Y_{it})}{\sum_{t=1}^{T} X_{it}} \tag{3.23}$$

Analogue calculations are also presented for the coverage. The relationship between the two measures corresponds to their relationship in classical QCA.
Using Euclidean distances, distance measures adjusted for Between Consistency (BECONS) and Within Consistency (WICONS) can then be calculated, which on the one hand provide information about the strength of the influence of time (high BECONS Distance values), and on the other hand about the heterogeneity of the sample (high WICONS Distance values) (cf. Garcia-Castro and Ariño, 2016, p. 67). If no time effects occur, a conventional analysis can be continued.
Even though Pooled Cross-Sectional Analysis has only a very decided application framework in which it allows the incorporation of time into QCA methods, it seems to be very robust and not afflicted with the same problems of other approaches. However, concordant to Kahwati and Kane (cf. Kahwati and Kane, 2019, p. 194), there are no published practical applications of this approach to be found.

3.5 QCA in the scientific community

Qualitative Comparative Analysis is, compared to many other quantitative and qualitative methods, still a very young method. Its general application in science should therefore be considered at this point in order to get an idea of its dissemination. The late emergence and above all the fact that decisive further developments and thus a higher number of applications took place at a time when the internet was universally available, favoured a very close documentation of the work and a networking of the users. The COMPASSS Network was founded in 2003. COMPASSS stands for "COMPArative Methods for Systematic cross-caSe analySis" and sees itself as an interdisciplinary, worldwide network of theoreticians and practitioners in the field of systematic, comparative case analysis with a focus on QCA as the method of choice (COMPASSS, 2017, p. 1). The database there collects monographs and journal articles that either deal with QCA as a method itself, or scientific papers that use QCA as a method. It is maintained manually and updated several times a month. There is no particular focus. Additionally, the network has been publishing a series of peer-reviewed working papers since 2009. These include methodological and theoretical papers on the further development of QCA as well as empirical studies. There are a number of special requirements to the quality of the methodology. The network is led by three groups of people, a management team, a steering committee and an advisory board. All the leading names in the "QCA scene" are represented there, including Charles Ragin himself.

All publications that were used to analyze the frequency of QCA applications were searched for exclusively in the COMPASSS database. Although it can never be assumed that it is possible to find all publications, it is assumed that an almost complete list can be found there [18].

Charles Ragin first developed the QCA as a way to gain new insights within his own scientific field. It is therefore not surprising that in the early years the method was used almost exclusively there, i.e. in sub-fields of political sociology and political science (cf. Marx et al., 2013, p. 121). These areas still dominate today as the field of application of QCA (cf. Wagemann et al., 2016, p. 2534). In 2011, for example, 51% of the publications were in the field of political science, the fields of sociology and economics and management account for 34% and 26% respectively (cf. Rihoux et al., 2013, p. 177) [19]. Other research areas were only marginally represented.

In the early years, the QCA was applied only hesitantly. From 1984, the year of publication of "The Comparative Method", until 1997, only 77 applications were documented, only 39 of them in peer-reviewed journals (cf. Marx et al., 2013, p. 122). However, these journals were of high quality, so that the discussion of the method soon gained a broader basis (cf. Marx et al., 2013, p. 121, Roig-Tierno et al., 2017, p. 20).

A strong increase could be observed from 2003 onwards, after the "ragin revolution" (Vaisey, 2009, p. 308), had received a new impetus through the integration of fuzzy-sets in 2000 (cf. Marx et al., 2013, p. 125). Also responsible for this turnaround was probably the availability of the software "fs/QCA" from 2004/2005, which enabled a simple, computer-based application of the procedure (cf. Roig-Tierno et al., 2017, p. 19). From this time on, the areas of application also expanded more and more, so that at the end of 2015 "only" 54% of the published work was still accounted for by the three research fields mentioned above (cf. ibid.). The most common languages of publication, apart from English, are French, German and Japanese (cf. Rihoux et al., 2013, p. 176).

It is noticeable that despite the strong methodological advantages of the fuzzy-set QCA, csQCAs continues to play a decisive role (cf. Thiem and Duşa, 2013b, p. 87). Until 2011, the percentage of published papers that used the crisp-set logic was still 72% (cf. Rihoux et al., 2013, p. 177). It

[18]Due to a restructuring of the website in 2018, it is no longer possible to verify the figures in the papers cited in the following.

[19]A higher total value than 100% is due to the fact that some works were located in multiple fields

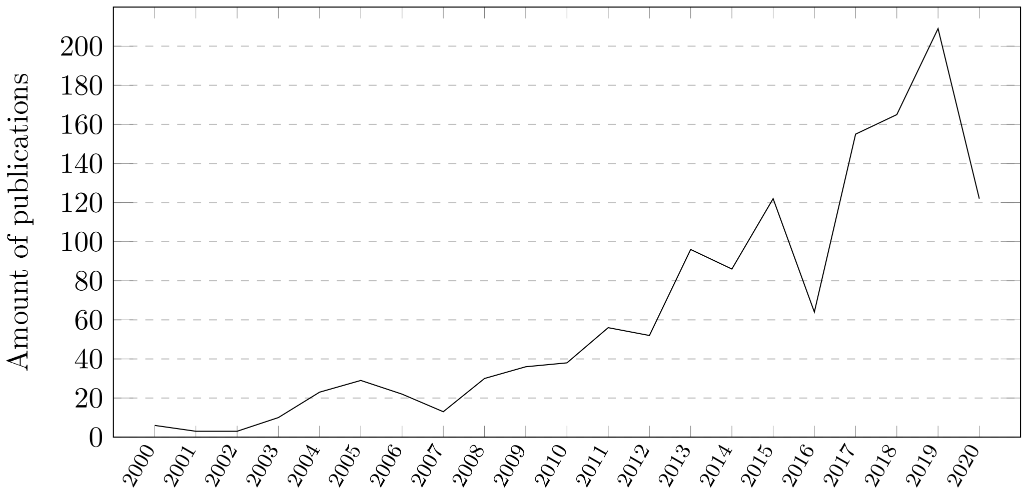


Figure 3.20: Amount of published QCA applications between 2000 and 2019

decreased slightly in the following years and was roughly balanced in 2015 at 50% (csQCA) to 47% (fsQCA) (cf. Roig-Tierno et al., 2017, p. 20). At 3%, the multi-value QCA is hardly used. Between its development in 2004 and 2012, only 10 applications were documented (cf. Thiem and Duşa, 2013b, p. 87), until 2015 there was only one further publication on this subject (cf. Roig-Tierno et al., 2017, p. 19).

By 2013, more than 200 peer-reviewed journals had published QCA-related papers. This shows that a certain "normalization" has taken place and that the method has been recognized in the scientific community. The strong user network may also have contributed to this: For example, there are lists of "QCA-friendly" journals (http://alrik-thiem.net/blog/ranking-most-qca-friendly-journals-some-observations/) or explanations of how research projects and results are best prepared for publication, and how to counter typical criticisms by reviewers (Kahwati and Kane, 2019, Chapter 9).

Figure 3.20 shows the current numbers[20] of QCA-related articles published in the COMPASSS database from the year 2000 onwards. Here again, the strong increase in the number of applications can be seen. After 2015, 64 papers are listed in the database for the following year, 155 for 2017 and 165 for 2018. For the current year 2020 there are 122, which means that in the last four years about as many papers were published as in all of the recorded years before combined.

3.6 QCA in nursing science

In a more decided way, the extent to which the nursing profession applies Qualitative Comparative Analysis in its research will now be examined. Attention should mainly be paid to the quality of the application, since some authors complain that the method is often applied incompletely and not oriented towards the theoretical foundations (cf. Patrick Emmenegger and Skaaning, 2013, p. 187, Rihoux, 2013, p. 242, Mahoney, 2004, p. 20).

3.6.1 Literatur research

With this goal in mind, several online nursing-related databases were searched, as well as the database of the COMPASSS website.

[20] status: 11/2020

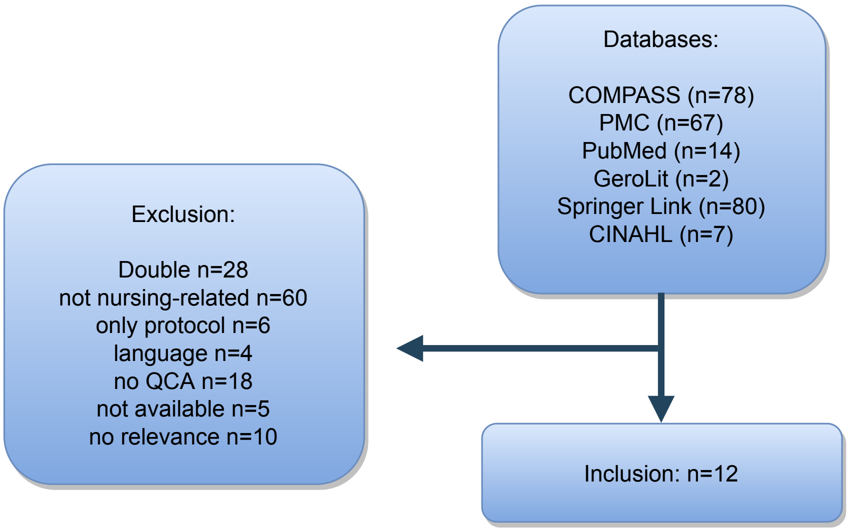


Figure 3.21: Literature research

For the literature search the search string "qualitative comparative analys" AND "nursing"[21] was chosen. Since the QCA still has a niche existence, the search should be as broad as possible and unnecessary restrictions should be avoided. The databases searched and the work found there can be seen in the figure 3.21.
Of 248 works, 28 were duplicates. 60 did not have a deeper relationship to nursing and were often medically oriented. In 18 cases no QCA was used as a method. Other works were either only available as abstracts, only a project outline, were not published in German or English or had no relevance for this search (e.g. collections of workshop topics of a conference). After excluding these results, 12 search results remained, which are presented below and evaluated with regard to the quality of the methodology [22]. The evaluation will be based on these criteria:

- Does the ratio of the number of conditions to the number of cases correspond to that specified by Marx and Duşa to avoid randomly consistent results?
- Are the conditions selected on the basis of theory?
- Are consistency and coverage values given?
- Are all solution forms (complex, intermediate and parsimonious) represented?
- Is the QCA also performed with negated outcome?
- Is the truth table displayed?
- Is the calibration process shown?
- Is the choice of threshold values in the calibration process explained?
- How are contradictory rows within the truth table handled?

[21]In the case of the COMPASSS database the term "qualitative comparative analysis" was omitted, since only works with suitable methodology are listed here anyway.
[22]The complete overview of all search hits can be found in the appendix

These essentially meet the requirements of the COMPASSS website for a publication there, as well as the best practice requirements of various other authors (Schneider and Wagemann, 2009, 2012; Greckhamer et al., 2018; Yamasaki and Rihoux, 2009; Greckhamer et al., 2018).

Table 3.31: Overview of the included studies

#	Titel	Author/s	Year	Type of publication	Field	Kind of QCA	Methodological quality [23]
1	The effect of family policies and public health initiatives on breastfeeding initiation among 18 high-income countries: a qualitative comparative analysis research design	Amanda Marie Lubold	2017	Journal article	Public Health	fsQCA	O
8	A Configurational Approach to the Relationship between High-Performance Work Practices and Frontline Health Care Worker Outcomes	Emmeline Chuang, Janette Dill, Jennifer Craft Morgan, Thomas R Konrad	2012	Journal article	Staffing/ Job satisfaction	fsQCA	-
9	Elderly and technology tools: a fuzzyset qualitative comparative analysis	Rana Mostaghel, Pejvak Oghazi	2017	Journal article	Technology	fsQCA	+
11	Mechanisms that Trigger a Good Health-Care Response to Intimate Partner Violence in Spain. Combining Realist Evaluation and Qualitative Comparative Analysis Approaches.	Goicolea I, Vives-Cases C, Hurtig AK, Marchal B, Briones-Vozmediano E, Otero-Garcia L, Garcia-Quinto M, San Sebastian M.	2015	Journal article	Public Health	fsQCA	-
70	The role of empathy and emotional intelligence in nurses' communication attitudes using regression models and fuzzy-set qualitative comparative analysis models	Gimenez-Espert MDC, Prado-Gasco VJ	2018	Journal article	Communication	fsQCA	-

[23] + = high, O = average, - = low

73	Strategies To Improve Mental Health Care for Children and Adolescents	Forman-Hoffman VL, Middleton JC, McKeeman JL, Stambaugh LF, Christian RB, Gaynes BN, Kane HL, Kahwati LC, Lohr KN, Viswanathan M	2016	Ministry report	Public Health	csQCA	O
76	Healthcare organization-education partnerships and career ladder programs for health care workers	Dill JS, Chuang E, Morgan JC.	2014	Journal article	Staffing/ Job satisfaction	fsQCA	Not to determine
78	The 'active ingredients' for successful community engagement with disadvantaged expectant and new mothers: a qualitative comparative analysis	Brunton G, O'Mara-Eves A, Thomas J.	2014	Journal article	Public Health	fsQCA	+
79	An example of qualitative comparative analysis in nursing research	Donnelly F, Wiechula R.	2013	Journal article	Education	csQCA	O
89	Using qualitative comparative analysis (QCA) in systematic reviews of complex interventions: a worked example	Thomas, James O'Mara-Eves, Alison Brunton, Ginny	2014	Journal article	Public Health	fsQCA	+
112	Involvement and structure: A qualitative study of organizational change and sickness absence among women in the public sector in Sweden	Maria BaltzerHugo WesterlundMona BackhansKarin Melinder	2011	Journal article	Public Health	csQCA	-
174	Configurations of factors affecting triage decision-making: A fuzzy-set qualitative comparative analysis	Ponsiglione, Cristina Ippolito, Adelaide Primario, Simonetta Zollo, Giuseppe	2018	Journal article	Acute care	fsQCA	-

3.6.2 Presentation and evaluation of the studies

The effect of family policies and public health initiatives on breastfeeding initiation among 18 high-income countries: a qualitative comparative analysis research design

The study by Lubold (Lubold, 2017) deals with the influence of macroscopic factors such as social policy and public health interventions on the natural breastfeeding of newborns in 18 OECD countries. The author uses fsQCA to analyze the data.
To describe the outcome "breastfeeding" 8 conditions were chosen and calibrated based on literature and theory (cf. Lubold, 2017, p. 4f.). This ratio of conditions (8) to cases (18) exceeds the benchmark developed by Marx and Duşa (cf. Marx and Duşa, 2011, p. 116f.). High consistency values could therefore also have occurred only by chance. Necessary conditions could not be identified. From the sufficient conditions, 6 solution paths with a consistency value >0.8 are identified. According to the author these represent the intermediate solution. No further solution paths are given. How the inevitably large number of logical remainders (at least 238!) was handled and which of them were used for the minimization process remains open. The raw coverage of the individual paths varies between 0.18 and 0.399; the unique coverage of 0.0 to 0.2 is significantly lower than the raw values. This suggests multiple overlaps of the individual solution paths and the existence of redundant paths, which were not excluded in the analysis (cf. Schneider and Wagemann, 2012, p.133f.). The values for solution coverage and solution consistency are high at 0.833 respectively 0.852. Lubold also calculates an intermediate solution for the negated outcome. Here she identifies two solution paths with a raw coverage of 0.381 and 0.366 and also significantly lower unique coverages of 0.082 and 0.067. The solution coverage with a value of 0.448 is not very meaningful, the solution consistency 0.833 is comparable to the positive outcome. Further problems in the methodology of the study are above all the lack of display of the truth table, which does not allow any conclusions to be drawn about the treatment of possible contradictory lines, as well as the omission of a representation of the basis on which the raw values were converted into their fuzzy set scores.
Overall, the study is methodologically well executed in large parts. However, the unclear handling of logical remainders is a major point of criticism, as it is not possible to reconstruct which assumptions were included in the minimization processes. The problems that arise, such as redundant paths and the condition-case-ratio, are higher order problems that are often not (yet) adequately dealt with in the literature and whose importance is not emphasized enough. The non-publication of the often very extensive truth tables is probably due to specifications of the journal. However, this could have been avoided by using appendices or digital additional material (Greckhamer et al., 2018, cf.).

A Configurational Approach to the Relationship between High-Performance Work Practices and Frontline Health Care Worker Outcomes

The study by Chuang and others (Chuang et al., 2012) examines the relationships between job satisfaction and perceived quality of care with “High-Performance Work Practices” (HPWP). These measures are incentives to encourage employees to perform better. The participants in the study are 661 so-called “frontline health care workers”. As conditions for the analysis of the two outcomes “job statisfaction” and “perceived quality of care”, 6 HPWPs were selected on the basis of theory and included in the analysis. Due to the high number of cases, the choice of six conditions does

not pose a methodological problem. The authors work with the software *Stata* and use the indirect method of calibration, which first sorts the variables by ranks and then standardizes them to values between 0 and 1 (cf. Chuang et al., 2012, p. 1468; Longest and Vaisey, 2008, p. 90). How many qualitative categories were chosen, which fuzzy values were assigned to which cases, and whether and which theoretical considerations were included, is not explained. According to Schneider and Wagemann, however, it is essential for the calibration "‘[to] make use of criteria for set membershio that are *external* to the data"’(Schneider and Wagemann, 2012, p. 33). Thus the calibration does not take place in a "black box", but remains transparent and comprehensible.
Necessary conditions could not be determined, but for the outcome “job satisfaction” two and for “perceived quality of care” four sufficient solutions were found. The consistency values lie between 0.81 and 0.86. The authors do not explain what form of solution is presented and an analysis for the negated outcome is not carried out. It is also noticeable in the table that, despite extensive population of the individual rows (>14), no contradictions with regard to the outcome at any point. The text also does not provide any information about the treatment of contradictions. In addition, all solutions contain only conditions in their positive form (A) and not once as a negative (~A/a). All in all, Chuang’s study seems very technical in its use of the QCA and does not show a deeper understanding of the method, which is absolutely necessary to produce interpretable results. Thus, the validity of the solutions found remains open.

Elderly and technology tools: a fuzzyset qualitative comparative analysis
The study by Mostaghel and Oghazi (Mostaghel and Oghazi, 2017) deals with the requirements for technology affinity in seniors. Two outcomes are defined: “perceived usefulness” and “perceived simplicity of use”. Five factors are defined as conditions and an fsQCA is performed based on 811 cases. Again, there are no problems regarding the condition-case ratio. The calibration of the raw values is done with the direct method via the three points: 0.05, 0.5 and 0.95 (Ragin, 2008; Mostaghel and Oghazi, 2017, cf.). However, it is not shown in which way these are backed up with concrete values and theoretical considerations for the individual conditions. The authors decide to present the complex solution exclusively, since with taht the often difficult decision about counterfactuals is avoided. Although this does not correspond to the required procedure to create the greatest possible transparency (cf. Schneider and Wagemann, 2012, p. 174), it does not contradict any fundamental, methodological requirement. However, it does testify to a deeper understanding and careful procedure. The two solution paths found for each outcome are presented with their raw, unique and solution coverage values, as well as the consistency values. However, the authors do not state whether a check for individual necessary conditions has been carried out. This process should always be done **before** the analysis of the sufficient conditions. Unfortunately, this study again lacks the possibility of accessing the truth tables and the performance of the analysis with negated outcome.
Overall, however, Mostaghel and Oghazi appear to be methodically informed and reflected.

Mechanisms that Trigger a Good Health-Care Response to Intimate Partner Violence in Spain. Combining Realist Evaluation and Qualitative Comparative Analysis Approaches
The study of Goicolea and others (Goicolea et al., 2015) deals with how health and care workers deal

with women who have been subjected to domestic violence. It develops an underlying theory with 10 factors which, according to the authors, are crucial for the successful handling and prevention of domestic violence. The data were collected from 15 teams of Spanish health centres.

A fuzzy set QCA was chosen because it should be used when the outcome or conditions are multinominal (cf. Goicolea et al., 2015, p. 7). While this is technically correct, the use of fsQCA for variables with multiple instances is not a compelling reason, but should be based on theoretical decisions. A variable like “wage” has continuous values and it is obvious to express this continuity by means of fuzzy values. However, if, for example, the employees of a small business are more or less at only two different ends of a spectrum (higher earners vs. low earners) and these ends are then still approximately homogeneous, a false precision (cf. Schneider and Wagemann, 2012, p. 37) is often pretended using fuzzy values. Goicolea et al. also makes such an error during data calibration: The conditions are calibrated by using the minimum, mean and maximum**raw** values as thresholds (0.05, 0.5 and 0.95) and not by using content-theoretical thresholds. This means that there is no calibration in the sense of QCA, but only an application of the values in relative distances to each other. Thus the values of the outcome “reaction to domestic violence” differ in part only by 0.02. To fill such a quantitative difference with meaning in terms of content is virtually impossible and leads to a **sham differentiation**. The used set of 10 conditions with only 15 cases also leads to problems with the reliability of the consistency values. At least 74 cases would have to exist for the targeted set (cf. Marx and Duşa, 2011, pp. 116ff.). The authors provide the truth table as an appendix and explicitly describe in the text that inconsistencies have been removed. How this was done is not explained. An intermediate solution is then calculated while retaining the easy counterfactuals ("‘[...]but retaining conditions that theoretically contribute to an explanation."’) (Goicolea et al., 2015, p. 7)). With 15 cases and 10 conditions, at least 1009 logical remainders to be checked must be assumed. Doing this line by line is extremely laborious and requires complex theoretical considerations for each constellation (Schneider and Wagemann, 2012, p. 171), which is very error-prone and can easily lead to untanable assumptions being included in the minimization process. However, the authors do not show whether and which other method was used.

Goicolea et al. then identify six solution paths in their solution with very high consistency values for both the individual paths and the overall solution (≥ 0.9). However, only the raw and not the unique coverage values are listed. An analysis with negated outcome does not take place.

Overall, the study shows some methodological weaknesses. The combination of calibration errors, the unachieved benchmark, and an incomprehensible handling of an enormous amount of logical remainders casts doubt on the validity of the results.

The role of empathy and emotional intelligence in nurses’ communication attitudes using regression models and fuzzy-set qualitative comparative analysis models (fsQCA)

The study by Gimenez-Espert and Prado-Gasco (Giménez-Espert and Prado-Gascó, 2018) examines the connections between empathy, emotional intelligence and the attitude towards communication with the patient. The data set consists of 460 cases and 9 conditions to be tested, 3 for each of the concepts empathy, emotional intelligence and attitude towards communication.

The presentation of the methodology is extremely diffuse throughout the course of the study and does not reveal a greater understanding of the processes involved. The authors vonstantly speak of **causal** conditions. However, causality can only be assumed in special cases of a QCA. The causal in-

terpretability of the solution paths can only be the case when using the most parsimonious solution, i.e. excluding all redundancies (see section 3.3.5). However, the two authors explicitly choose the intermediate solution. A truth table is not presented, but the raw values for the thresholds of 0.10, 0.5 and 0.9 used for calibration are. However, these are not theoretically justified. In the first step, an analysis is carried out for each condition and for each positive and negative outcome. The three outcomes correspond to the three sub-dimensions of the concept “attitude towards communication”. Thereby, solution paths with 6, 5 and 19 paths are identified. Of these, the authors select the three “most significant[24]” and list them in a Fiss chart. In the last analysis run, seven individual paths of the solution are also considered “inadequate” due to low raw coverage (<25%) (Giménez-Espert and Prado-Gascó, 2018, p. 14). This demonstrates a profoundly flawed understanding of the QCA. Because even with lower coverage, the paths are part of the calculated overall solution. They can be omitted by means of Boolean minimization, but cannot simply be ignored. With one exception, the unique coverage values of the displayed paths tend towards 0, which means that there is almost complete redundancy of the solutions, which rules out a causal interpretation, as hoped by the authors.
Overall, the implementation of QCA in this study has failed.

Strategies To Improve Mental Health Care for Children and Adolescents
The study by Forman-Hoffman and others (Forman-Hoffman et al., 2016) examines effective strategies for improving mental health in children and adolescents. To this end, the results of 17 studies are analysed. The use of the csQCA is only a marginal part of the comprehensive report.
7 conditions were selected on the basis of literature and 2 outcomes were defined. A calibration table is attached to the appendix, which defines the conditions and outcomes and sets a threshold value for the values "0" and "1". However, no reasons are given why these values were set. The exact composition of the six analysed configurations remains equally open. The authors point out the problem of limited diversity (Forman-Hoffman et al., 2016, p. H-1) and therefore limit themselves in the selection of conditions. The consistent avoidance of a formalized representation supports the difficulty of extracting appropriate information. Due to the solution paths given, ≥ 3 conditions per model can be assumed.
Forman-Hoffmann and others check in advance for necessary conditions and calculate an intermediate solution with 7 solution paths. There is an explanation for dealing with contradictions. For each of the paths, they report raw and unique coverage values, as well as consistency values, and the values for the overall solution. For the resentation they use a Venn diagram. Again, there is no formalized notation and the size of the ellipses does not reflect the differences in coverage values.[25]
Overall, the methodological implementation is decent. However, writing out names for the conditions and not using Boolean operators makes the presentation of the results hardly comprehensible.

Healthcare organizationeeducation partnerships and career ladder programs for health care workers
Dill et al. (Dill et al., 2014) are searching for factors for the success of so-called “career ladder programs”, which offer care workers further training and promotion opportunities without having

[24] For the authors this means, the paths with the highest raw coverage values
[25] For the use of Venn diagrams to represent QCA solutions see Schneider and Grofman (2006, p. 25ff.).

to interrupt their professional activities.
For this purpose 4 different outcomes and 7 conditions were identified based on existing literature and theoretical considerations. Due to the high number of cases (291 nurses and 347 key informants), the authors easily achieve the necessary ratio of conditions and case numbers.
Just as Chuang et al. (2012) before, the indirect method is used for the calibration of continuous variables, and here too there is no transparent presentation. Variables identified from qualitative interviews were assigned fuzzy values in a consensus procedure. Possible theoretical considerations on this are not, as methodologically required, made explicit (cf. Berg-Schlosser and Meur, 2009, p. 28).
A most parsimonious solution was then calculated, which includes all logical remainders in the minimization process (cf. Dill et al., 2014, p. 68).
However, since most of the relevant information on the implementation of the fsQCA is contained in the appendix of the study and this was not available, a final assessment of the methodological quality of the study cannot be made here.

The 'active ingredients' for successful community engagement with disadvantaged expectant and new mothers: a qualitative comparative analysis

The study by Brunton, O'Mara-Eves and Thomas (Brunton et al., 2014) searches for successful ways of successfully involving disadvantaged mothers in community service. A secondary analysis of 24 studies was carried out. 4 theoretically derived ways of involving women in community work are checked for their existence within the study and correspond to the codes "0" and "1". The outcome is not decisive, but only the effect size found. This is calibrated qualitatively into one of four fuzzy values (0, 0.33, 0.66 and 1). The threshold values are transparent but not justified. In addition to the truth table for the positive and negated outcome, the authors also provide the complete fuzzy-set data matrix and a table with all 4^2 possible combinations. Logical contradictions in the lines of the truth table "where solved through discussion"(Brunton et al., 2014, p. 2852). The transparent handling of contradictory lines is a methodically good practice. What actions were taken afterwards (e.g removal of the respective case) would have been even better to present. The authors present the most parsimonious solution paths for both outcome poles and indicate the corresponding unique coverage and consistency value. However, the coverage value of the overall solution is missing.
Overall, the Brunton study has a very high methodological quality. The discussion of all possible solutions and a more theory based calibration would still be desirable. The authors do not only belong to the group of QCA users, but are also involved in a creative further development of the method and publish methodological papers in this regard (Thomas et al., 2014).

An example of qualitative comparative analysis in nursing research

Donnelly and Wiechula (Donnelly and Wiechula, 2012) examine the influence of different factors on practical assignments of female students during the training period. The main focus is on the exemplary application of QCA in nursing science. 16 cases are analysed by means of 5 conditions for sufficient factors for the outcome "Performing interventions concerning patient-sensitive outcomes". The conditions as well as the outcome are theoretically well-founded. The thresholds of dichotomization, for performing a csQCA, are presented by the two authors, but in three of two cases they remain unfounded. In addition, the choice of five conditional factors leads to the problem

of randomly consistent values with such a small number of cases (Marx and Duşa, 2011). However, this cannot be further examined, since no fit parameters such as consistency or coverage are given. The calculated solution is, as can be derived from the given truth table, a conservative solution, since no assumptions about logical remainders are made and contradictions are not included in the solution term. The presentation of the solution is both as a Boolean term and as a Venn diagram. However, an analysis of the negated outcome is not carried out.
Overall, the study shows the QCA process very clearly and well explained. Some methodological problems are of minor importance, such as the specification of only one solution or the execution only with positive outcome. On the other hand, the omission of the parameters of fit, which Ragin already presented in an article in 2006 (Ragin, 2006), is a significant problem. For not only the question **wether** a sub- or superset relationship between outcome and conditions exists, but also how strong this relationship is, or whether it is a trivial relationship. In this regard the description of the methodology is good, but incomplete.

Using qualitative comparative analysis (QCA) in systematic reviews of complex interventions: a worked example

The paper by Thomas et al. (Thomas et al., 2014) is, as already in Brunton et al. (2014), an application of QCA in the context of systematic reviews, that is based on the work of Kahwati et al. (Kahwati et al., 2016). It serves primarily as an exemplary application (Thomas et al., 2014, p. 2). The authors select studies from a review that examined the influence of public health and health promotion measures on the breastfeeding behaviour of mothers.
For this purpose, 3 conditions were theoretically selected, of which 2 were replaced by other conditions in the course of the study. In connection with 12 cases, this results in an adequate condition-case-ratio.
The calibration of the conditions is performed as a crisp set, since only the presence/application of different procedures within the studies is checked. A more detailed justification is therefore not necessary. The threshold values for the four-level fuzzy outcome is linked to the found effec size. The exact reason for their differentiation remains unclear. The authors first create truth tables from the first three conditions, both for the positive and the negative outcome, and calculate the raw consistency values. Since there is only one consistent solution path that is covered by a single study, the authors decide to construct two new conditions in order to obtain more information in their solutions. This iterative approach is strongly anchored in the roots of the method within the comparative social sciences. Especially Ragin postulates this "case-related" approach (Ragin, 1987, 2000; Berg-Schlosser and Meur, 2009), while other authors in the QCA field have a more "technically" approach (Schneider and Wagemann, 2007, 2012; Mahoney, 2004).
For this second model, a most parsimonious solution is calculated, stating all necessary parameters of fit, which, due to the saturated truth table and a comprehensibly documented, well-founded solving of the contradictions, can be considered methodologically sound.
In summary, the study is a perfect example of a well performed and transparently documented QCA, as well as an innovative application. Since above all it is of a mostly demonstrative character, more complex problem-solving procedures, such as the use of logical remainders, are left out in favor of a stringently explained step-by-step guide. Still, reference is always made to corresponding, more detailed literature. All in all the paper is thus more of a methodological paper.

Involvement and structure: A qualitative study of organizational change and sickness absence among women in the public sector in Sweden

The study by Baltzer et al. (Baltzer et al., 2011) examines the connection between changes in the working environment and the absence of employees due to illness.

To this end, 22 relevant topics were identified from interviews. These were sorted subjectively (similar to Dill et al. (2014)) according to relevance for the production of the outcome and first the most important 10, then the most important 5 were selected as conditions for the performance of a csQCA. This procedure has little traceability for the reader and is not consistent with authors such as Berg-Schlosser and de Meur who demand that "[f]or each condition, [...] a clear hypothesis regarding its connection to the outcome [is formulated]; if possible [...] in the form of a statement about necessity and/or sufficiency" (Berg-Schlosser and Meur, 2009, p. 28). It remains open according to which criteria the topics were weighted, or whether an (implicit) hypothesis was formulated at all. Baltzer and others realize themselves that the number of ten conditions in 21 cases is too large and reduce their model accordingly, but this leads to the same results (Baltzer et al., 2011, p. 5).

The calibration is very simple in this case, since the occurrence or non-occurrence of a topic in the 21 cases/interviews was coded with "1" or "0". The "truth table" listed by the authors is merely a data matrix with calibrated values, since the cases and not the possible configurations are listed in the series.

All logical remainders have been included in the minimization process in the two presented, sufficient solutions for the positive as well as the negated outcome. The authors have considered them as not contradictory for the existing cases. According to Ragin, this process includes the examination of the non-empirical existing cases with regard to the decision whether they plausibly contribute to the achievement of the outcome (Ragin, 1987, 2008). With five conditions (2^5=32), minus the 17 empirically existing configurations, 15 cases remain for which directional expectations must be formulated. However, it cannot be inferred from the text whether this was done on the basis of theoretical considerations, or was a fundamental decision to minimize the solution path in the best possible way. However, this procedure can mean that untenable counterfactuals are included in the minimization, which render the resulting solution problematical.

The presentation of the results themselves remains unclear. According to the text, one solution was found for the outcome "high absence due to illness" and four solutions for the outcome "low absence due to illness". In the corresponding table there is one solution term per outcome with three paths connected by "OR". Furthermore, no parameters of fit are given, neither for the overall solutions nor for the individual paths.

All in all, the paper shows an incorrect understanding of the processes of a QCA. A theory-free selection of the conditions, a number which does not meet the benchmark of Marx and Duşa (Marx and Duşa, 2011), the probable entry of difficult counterfactuals into the minimization process, as well as the lack of consistency or coverage values and an unclear representation of the solution, cast strong doubts on the validity of the results.

Configurations of factors affecting triage decision-making

Ponsiglione and others (Ponsiglione et al., 2018) investigate in their study the influence of different

configurations on the accuracy of triage in emergency rooms.
For this purpose, the authors derive 7 conditions from the literature and construct 25 cases in 3 levels of difficulty, which have to be assessed by the participating nurses. The calibration in fuzzy values is done "automatically"(Ponsiglione et al., 2018, p. 2160) using software and anchor points. A theoretical justification is missing. A truth table is also not provided. Thus, a handling of possible contradictory lines is not comprehensible. For each of the three categories a separate fsQCA with the conditions is then calculated. This leads to the fact that in two of three analyses there are fewer cases than conditional factors[26]. Only complex solutions are chosen in order to do justice to the explanatory character of the study and to show all possible solution paths to an exact triage (cf. Ponsiglione et al., 2018, p. 2160). To these Ponsiglione present all coverage and consistency values; however, the significance of the latter is limited by the failed benchmark. Overall, the study is described clearly and comprehensibly, except for the missing truth table, but the methodological errors limit the validity of the result.

This comprehensive account of the use of QCA in nursing science reveals that in many cases a deeper understanding of the method in application is still lacking. Truth tables, which are essential for the comprehensibility of the methodological work, are rarely made available in their full extent. Calibration processes are almost exclusively carried out purely mechanistically by means of software and not, as required, guided by theory. This behavior coincides with the finding of other authors that the QCA is becoming increasingly elaborate and, in particular, an increase in technical "refinements" can be observed (cf. Rihoux, 2013, Mahoney, 2004).
That Qualitative Comparative Analysis can also be understood as a methodology that is to determine the entire research process (cf. Berg-Schlosser et al., 2009; Schneider and Wagemann, 2012; Ragin, 1987, 2000, 2008), is not recognizable in any of the papers. Whether this is a disadvantage that influences the quality of the works or just a postulate that does not prevail in practice can be discussed. However, in the eyes of the author, the validity of the results found is not affected by this.
It can also be seen that more recent methodological findings, such as the problem of high consistency values even with random, non-empirical data, as Marx and Duşa have discovered (cf. Marx and Duşa, 2011), have not yet found their way into current studies either. This may be due to the fact that the only more comprehensive textbook on Qualitative Comparative Analysis, "Set-Theoretic Methods for the Social Sciences" (Schneider and Wagemann, 2012), was already been published in 2012 and has not been updated since then. Since many authors also often refer only to the original works of Ragin (Ragin, 1987, 2000, 2006, 2008), even concerns about the inclusion of different kinds of untenable assumptions and difficult counterfactuals in the minimization process, as they are discussed by Schneider and Wagemann (Schneider and Wagemann, 2012, cf.), find no entrance into the methodological considerations. More profound findings, such as those on the causal interpretability of the variously solutions, as presented by Baumgartner (Baumgartner, 2014), have not been taken into account in the current publications of nursing science.
Therefore with regard to the **first research question** it can be stated: Yes, an application of Qualitative Comparative Analysis is taking place. Nursing science has made use of this method

[26] condition-case-relations *simple cases:* 7:13, *moderate cases:* 7:6, *complex cases:* 7:6 (cf. Ponsiglione et al., 2018, p. 2160)

for its research. However, the number of research papers found that use QCA is manageable. This may be mainly due to the fact that the method has become well established in the social sciences (see 3.5), but not to the extent that one can speak of a self-evident application as a mainstream method. Rihoux et al. already stated “a phase of mainstreaming” (Rihoux et al., 2013, p. 183) in 2013, but also made further development dependent on the progress made in terms of methodological refinements, developed software and dissemination of new textbooks. The methodological development is very lively. Already during the writing of this thesis a number of new publications (Duşa, 2019a; Rutten, 2020; Rubinson et al., 2019) appeared, which gave new impulses and partly made it necessary to revise or supplement certain sections. At the same time, such publications are only of interest to already informed users and hardly provide for a further dissemination of the method. Rather, textbooks must be taken into focus. However, there has been a vacuum here for quite some time. After “Set-Theoretic Models for the Social Sciences” by Schneider and Wagemann (Schneider and Wagemann, 2012) it took until 2019 for Kahwati and Kane’s “Qualitative Comparative Analysis in Mixed Methods Research and Evaluation” (Kahwati and Kane, 2019) to be released as a comprehensive, practice-oriented textbook. It incorporates many of the latest findings and common applications. The chapter that ultimately deals with QCA in Mixed Methods is only about 20 pages long and therefore it is surprising why the book was published under this title. It is to be feared that it will prevent interested people from seeing this book as what it actually is: A clear and understandable, up-to-date introduction to QCA, which is long overdue since 2012 and can serve a further spreading of QCA within the scientific community.

Many of the practical applications found also suffer from the fact that they have not included methodological developments of recent years in their work. As mentioned above, there is still a strong focus on Ragin’s original works, which are, however, in parts outdated by more recent developments and can no longer be implemented 1:1. Therefore it can be said also with regard to the **second research question** that many of the works under consideration are of rather low, methodological quality. They either make blatant errors that contradict the basic assumptions of the QCA, are incompletely applied, or overlook new insights into the method. Nevertheless, there are several prime examples of a QCA among the studies that show that an application to nursing science topics can succeed and provide meaningful results. The QCA poses special challenges for its user. On the one hand, it comprises a large proportion of qualitative elements that require the researcher to have a sound knowledge of the subject under investigation, and on the other hand, it also includes quantitative elements that tempt the user to apply the method “mechanistically” to a data set (cf. Rihoux, 2013, p. 242,Mahoney, 2004, p. 20). Thus, even with a purely “mathematical” calibration and theory-less choice of conditions, an apparently meaningful result can be achieved, which, however, is untenable from a methodological point of view. Such “quick-and-dirty” procedures can never be completely avoided and are also a problem of other methods (e.g. wrong data levels in correlation tests). However, they must be viewed critically by vehemently referring to the basic assumptions of the QCA. Many of the points of criticism of the method ultimately result from misunderstood demands on the method (see below).

Chapter 4

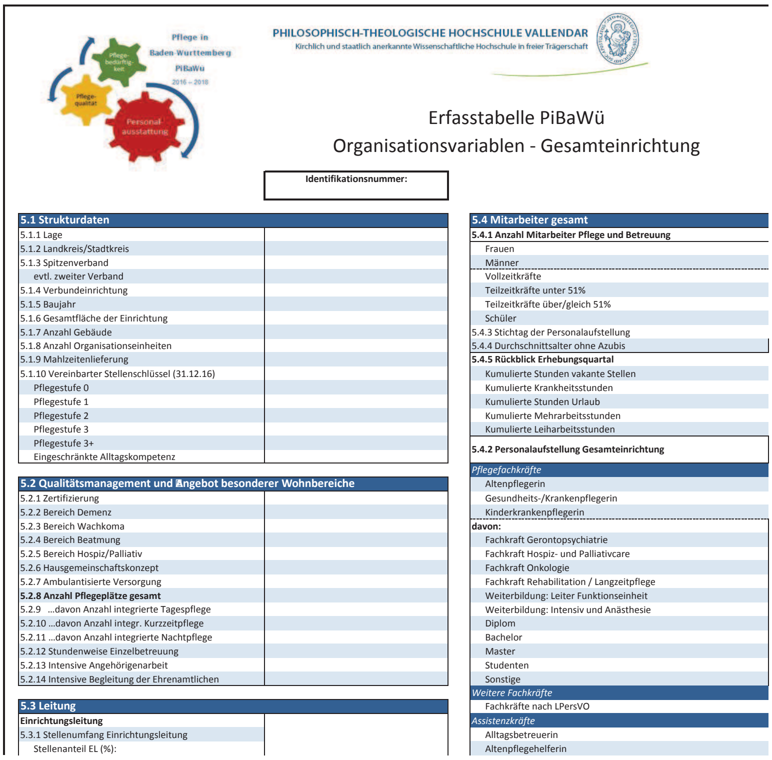
Collection of organizational factors in the research project “PiBaWü”

The database for this thesis derives from the research project “PiBaWü - Pflege in Baden-Württemberg”. It was conducted between January 2016 and December 2018 under the direction of Prof. Dr. Albert Brühl (PTH Vallendar) in cooperation with Prof. Dr. Katarina Planer (Bern University of Applied Sciences/University of Esslingen). The project was funded by the Ministerium für Soziales und Integration[1] and supported by the Liga der freien Wohlfahrtsverbände Baden-Württemberg e.V.[2]. The aim was to investigate the interactions between the need for nursing care, the quality of nursing care and assessment of staffing. Crucial for the conduction of this study was the introduction of a new concept for the need for care and, in combination with this, a new evaluation procedure for the differentiation by Pflegegrade (cf. Brühl and Planer, 2019).
The data was collected on three different levels: On the one hand, **personal data** of the persons in need of care. These largely consisted of the items of the Neues Begutachtungsassessment[3] (NBA) for long-term care. They were enriched by variables which proved to be informative in the previous project “PiSaar”. Further data was also collected at **organizational level**. Here, information was separated into those concerning the entire facility and those concerning individual nursing wards. Also a survey of **quality indicators** was carried out twice at intervals of 6 months at the resident level. These consisted of parts of the "Instrument zur Beurteilung der Ergebnisqualität in der stationären Altenpege[4]" (Wingenfeld et al., 2011) proposed by Wingenfeld and others and the “Erfassungsbogen Mobilität”[5] (EBoMo) by Zegelin and Reuther (N.N., 2017a). In addition, an investigation was conducted on the total time spent by nursing home staff interacting with residents. All employees who had direct contact with the elderly were provided with an additional person during the daytime services, which measured the time spent with the different residents using a stopwatch over a period of 48 hours.
Since the effort for the participating institutions was, as expected, high and high demands were made in terms of invested time, personal contribution and staff, it was part of the study concept that representatives of the institutions were involved in the planning and design of the study processes. In this way, the project team was able to ensure that the participants remained motivated through opportunities for participation. In addition, the project team benefited from the everyday practical expertise of the home representatives, which enabled them to improve, supplement or even remove items. For this purpose, so-called project group meetings were held at four points in Baden-Württemberg over the period of the first research year. At each of these meetings, one of the topics “Residents’ data”, “Organizational data”, “Quality indicators” and “Data collection” were discussed. Since the participating institutions were located all over Baden-Württemberg, as

[1] Ministry of Social Affairs and Integration
[2] League of Independent Welfare Associations Baden-Württemberg e.V.
[3] New Assessment Tool
[4] Instrument for assessing the quality of outcomes in inpatient nursing care for the elderly
[5] Mobility Record Form

a federal state, and were in some cases far apart from each other, different regions were chosen for the meetings in order to include as many participants as possible. For this reason, the project group was also designed to be open so that any institution that showed interest in one topic could participate, but was free to stay away from another topic. For each meeting, the project team designed a template of variables, which was then presented and discussed by the participants. The results were summarized, sent to the participants for validation and the changes were then reported via a newsletter to all study participants. The collected data thus move in a space of theoretical considerations of the project team, practical experiences of the nursing home representatives and economic considerations of feasibility.
At the end of 2016, a handbook was available in which all variables were listed separately by topic. For each variable, the modalities of its collection were also defined and how it is coded in the data entry form. Before the start of the data collections, multipliers from the participating institutions were trained to explain the use of the data tables on the one hand and the time survey on the other. They were available as contact persons for the staff on site and were usually significantly involved in the collection of organizational and resident data.
From the second project year 2017 onwards, the nursing homes could then enter their data in the Excel-based data tables. Care was taken to ensure that most of the information was process-generated data that the responsible persons were already familiar with or could be taken from existing documents with little effort. In this way, an attempt was made to reduce the time required as much as possible. The data tables were designed by the project team in such a way that the input into the respective cells was limited to a range of meaningful values. For example, the number of organizational units within an institution could only be entered as integers between 1 and 99. Drop-down menus were mainly used in the context of NBA Items, but also everywhere else where there was a predetermined number of possible answers. Text entries were completely avoided in order to facilitate filling in the form. This, on the one hand, ensured that e.g. no terms had to be typed in by hand and, on the other hand, allow conversion into numerical values in the background of the table, which made the error-prone manual reading of values by the project team afterwards unnecessary. In addition, an integrated check field drew the attention of the filler to logical errors if, for example, the sum of female and male employees did not match the total number of employees. Overall, the design of the survey instrument was aimed at obtaining simple, uniform datasets across all study participants that were resistant to slip errors. This was supported by a plausibility check following the return of the tables to the project team. Table 4.1 shows an extract from the data table for organizational data of the entire institution. The data collected here is divided into the following areas:

- structural data
- quality management and offer of special care units
- management
- total employees
- cooperations
- conception of care



PHILOSOPHISCH-THEOLOGISCHE HOCHSCHULE VALLENDAR
Kirchlich und staatlich anerkannte Wissenschaftliche Hochschule in freier Trägerschaft

Erfasstabelle PiBaWü
Organisationsvariablen - Gesamteinrichtung

Identifikationsnummer:

5.1 Strukturdaten
- 5.1.1 Lage
- 5.1.2 Landkreis/Stadtkreis
- 5.1.3 Spitzenverband
  - evtl. zweiter Verband
- 5.1.4 Verbundeinrichtung
- 5.1.5 Baujahr
- 5.1.6 Gesamtfläche der Einrichtung
- 5.1.7 Anzahl Gebäude
- 5.1.8 Anzahl Organisationseinheiten
- 5.1.9 Mahlzeitenlieferung
- 5.1.10 Vereinbarter Stellenschlüssel (31.12.16)
  - Pflegestufe 0
  - Pflegestufe 1
  - Pflegestufe 2
  - Pflegestufe 3
  - Pflegestufe 3+
  - Eingeschränkte Alltagskompetenz

5.2 Qualitätsmanagement und Angebot besonderer Wohnbereiche
- 5.2.1 Zertifizierung
- 5.2.2 Bereich Demenz
- 5.2.3 Bereich Wachkoma
- 5.2.4 Bereich Beatmung
- 5.2.5 Bereich Hospiz/Palliativ
- 5.2.6 Hausgemeinschaftskonzept
- 5.2.7 Ambulantisierte Versorgung
- **5.2.8 Anzahl Pflegeplätze gesamt**
- 5.2.9 ...davon Anzahl integrierte Tagespflege
- 5.2.10 ...davon Anzahl integr. Kurzzeitpflege
- 5.2.11 ...davon Anzahl integrierte Nachtpflege
- 5.2.12 Stundenweise Einzelbetreuung
- 5.2.13 Intensive Angehörigenarbeit
- 5.2.14 Intensive Begleitung der Ehrenamtlichen

5.3 Leitung

Einrichtungsleitung
- 5.3.1 Stellenumfang Einrichtungsleitung
  - Stellenanteil EL (%):

5.4 Mitarbeiter gesamt

5.4.1 Anzahl Mitarbeiter Pflege und Betreuung
- Frauen
- Männer
- Vollzeitkräfte
- Teilzeitkräfte unter 51%
- Teilzeitkräfte über/gleich 51%
- Schüler

5.4.3 Stichtag der Personalaufstellung
5.4.4 Durchschnittsalter ohne Azubis

5.4.5 Rückblick Erhebungsquartal
- Kumulierte Stunden vakante Stellen
- Kumulierte Krankheitsstunden
- Kumulierte Stunden Urlaub
- Kumulierte Mehrarbeitsstunden
- Kumulierte Leiharbeitsstunden

5.4.2 Personalaufstellung Gesamteinrichtung

Pflegefachkräfte
- Altenpflegerin
- Gesundheits-/Krankenpflegerin
- Kinderkrankenpflegerin

davon:
- Fachkraft Gerontopsychiatrie
- Fachkraft Hospiz- und Palliativcare
- Fachkraft Onkologie
- Fachkraft Rehabilitation / Langzeitpflege
- Weiterbildung: Leiter Funktionseinheit
- Weiterbildung: Intensiv und Anästhesie
- Diplom
- Bachelor
- Master
- Studenten
- Sonstige

Weitere Fachkräfte
- Fachkräfte nach LPersVO

Assistenzkräfte
- Alltagsbetreuerin
- Altenpflegehelferin

Figure 4.1: Snippet from the survey table of PiBaWü on organizational variables

- ethical Instruments

It consists of a total number of up to 212 possible entrys for the facility in general and 110 possible entrys for every care unit[6]. Parts of these refer to items for which multiple answers were possible (areas "cooperations" and "ethical instruments") or were only to be filled in if staff with specific qualifications were working in the institution or care unit. This significantly reduced the actual time required for completion. A complete list of all variables collected in the project is found in the appendix.

[6] Plus an additional four details for each person who was present on the care unit in the time of the data collection.

Chapter 5
Application of QCA

In the following, it will be clarified whether and what influence organizations in itsself have on the fall rate of residents of nursing homes.
Falls represent a great danger for older people both in the home environment and in health care institutions. In contrast to children and younger adults, senior citizens are much more susceptible to severe fall consequences such as fractures due to degenerative processes. For nursing home residents, fall injuries are the most common reason to be admitted to hospital. In addition to purely physical damage, psychological effects such as seclusion and anxiety are common consequences of falls (cf. Balzer et al., 2013, p. 15). From a health economic perspective, the costs incurred also play a not inconsiderable role (cf. ibid., p. 17). In contrast to other phenomena, falls are a very extensively and comprehensively studied problem in older people (e.g. Cameron et al., 2018; McClure et al., 2005; Hopewell et al., 2018; Kendrick et al., 2014 etc.).
However, the focus for the causes is almost exclusively on person-related risk factors. Also the expert standard of the “Deutschen Netzwerk für Qualitätsentwicklung in der Pflege”[1] (DNQP) names primarily inhabitant intrinsic factors. The contextual factors refer, for example, to the characteristics of the caregivers, the social environment or care processes (cf. Balzer et al., 2013, pp. 217f.). Whether organizational factors, that go beyond an individual context, have an influence remains unclear.

In order to get a first overview of the current situation, which studies have already dealt at all with the influence of nursing homes as an organization on resident outcomes, a literature review was conducted. Since only eleven relevant studies could be found overall, they were reviewed individually[2]. Across the findings conditions from the four topic areas were identified: **Qualification of leadership, characteristics of the facility, special care units and staff**. The selected outcomes are very diverse and range from elusive concepts such as quality and satisfaction to mortality rates (see table 5.1). Some studies are over 25 years old and it is to be expected that their results will only reflect the current situation in nursing homes to a limited extent. Apart from this, many of the studies use person-focused conditions: The professional experience of an institution manager or a director of nursing, as well as the qualification of registered nurses sure represent on the one hand aspects of an organisation. On the other hand, they are not abstract enough to serve the research question posed.

Table 5.1: Overview of found literature and their topics

	Condition

[1] German Network for Quality Development in Care
[2] The complete list is found in the appendix

	Qualification of leadership	Charakteristics of facility	Special care units	Staff
Quality	Bravo, 1999	Geraedts, 2016 Xu, 2013		Hyer, 2011
Statisfaction		Lucas, 2007		Lucas, 2007
Restraint use	Castle, 2015	Castle, 2000 Zinn,1993	Castle, 2000	
Pain	Castle, 2015			
Decubitus	Castle, 2015 Ooi, 1999	Zinn,1993		Ooi, 1999
Mortatily	Spector, 1991	Zinn,1993		
Fall		Zimmermann 2019	Zimmermann 2019	

The decisive criterion, however, which limits the usefulness for these papers, is that they are primarily international studies. Only the studies of Zimmermann et al. and Gaeredts et al. refer to German nursing homes. As was explained at the beginning of the thesis, German nursing homes are influenced by a large number of regulations and laws. In addition, there are the nature of the training and the areas of competence of the nursing staff, which cannot simply be equated with foreign situations. This leads to the fact that Germany has a very specific structure of nursing homes, which must be treated as such. The transfer of international results is therefore seen as problematic.

The study by **Geraedts et al.** examines the connections between profit orientation or daily prices and the quality of nursing homes (cf. Geraedts et al., 2016, p. 3). The MDK's catalogue of criteria is used for this purpose. The fact that these "Pflegenoten[3]" are hardly suitable for depicting a complex construct such as quality has meanwhile also reached the general public and is the subject of journalistic reports (e.g. `https://www.stern.de/wirtschaft/news/pflegeheim--gute-bewertung-bei-mieser-pflege---wie-kann-das-sein--7198786.html`). The values published in the study also show the invariance and bias in these examinations: The lowest average results on a scale from 0 to 100 are 91.82, on a five-level scale they are 4.23 (cf. Geraedts et al., 2016, p. 7).

Zimmermann et al. deal with the influence of various organizational factors on falls of residents. The conditions chosen are: Staff mix, home-like care units (HLU), dementia care units (DCU), region, location, facility size, occupancy rate and resident mix (cf. Zimmermann et al., 2019, pp. 507f.). Using regression, these were then applied to the 18.985 data sets of residents from 220 nursing homes, most of which were located in North Rhine-Westphalia and Bavaria (cf. ibid., pp. 5f.). Significant results were shown for all conditions except occupancy rate staff and resident mix.

However, this study also has methodological weaknesses. Since the approximately 19.000 residents' data were used as a starting point for the analysis and the organizational variables were projected onto them, the sample appears to be much larger than it was in reality. Ultimately, only the 220

[3] nursing grades

facilities to which the respective organizational factors can be assigned would be available for analysis. Such an oversized sample makes even the smallest effects disproportionately significant. However, by focusing on this study, it should be examined whether the results, although obtained on a problematic analytical basis, can be reproduced, or whether Qualitative Comparative Analysis can be used to find other solutions or configurational influences on falls.

5.1 Configurational Model

The study by Zimmermann et al. has provided first approaches and a theoretical basis for the creation of a configurational model. However, since, as described, the empirical evidence is very thin as far as concrete relationships between organizational factors and the rate of falls are concerned, the construction of a model must primarily be based on well-founded assumptions and thus give the QCA an exploratory character. This is in line with the intuitive approach described by Yamasaki and Rihoux for the selection of conditions (cf. Parente and Federo, 2019, p. 402)) (see section 3.3.1).
As **Outcome** the relative frequency of falls in facilities is chosen (coding: $FALL$). Corresponding data is available through the PiBaWü on the resident level and has to be aggregated for use.
Regarding the conditions, Zimmermann presented a comprehensive review of the existing literature with her dissertation (Zimmermann, 2019). The evidence here, however, points in different directions. In addition, there are virtually no concrete studies that explicitly investigate the organizational influence on falls. Zimmermann primarily collects studies that document any kind of influence on the quality of care and on resident outcomes (cf. Zimmermann, 2019, pp. 37ff.).
For the **size of facilitys** (coding: BIG), the thesis of Castle and Engberg is therefore supported that “small facilities are more able to cater to individual resident needs due to the familiarity and bonds that can be formed between residents and staff.” (cf. Castle and Engberg, 2008, p. 467) (also: Castle and Engberg, 2007, p. 226). For Germany, Weiß, Sünderkamp and Rothgang report significant, but very small, positive influences of the size of the facility on the nursing grades (cf. Weiß et al., 2014, p. 95)[4].
Regarding **home-like care units** (coding: HCU) a similar thesis is presented. Through accommodation designs that “feel less like medical institutions and more like homes” (Gray and Farrah, 2013, p. 4) and small groups of residents, a more intimate atmosphere is created in which people remain cognitively active for a longer time. Since cognitive impairment is a risk factor for falls (cf. Balzer et al., 2013, pp. 55f.), an environment that positively influences such impairments should also have an impact on the rate of falls. A review of the effectiveness of home-like models was able to detect at least slight tendencies for such a positive influence in some areas (cf. Gray and Farrah, 2013, pp. 8ff.).
Dementia care units (coding: DCU) are another form of special care units that are said to have a positive impact on the condition of their residents compared to traditional long-term care (cf. Zimmermann, 2019, p. 44). Weyerer et al. report for some factors, such as interactions with caregivers and participation in activities, better results for people in DCUs that indicate a positive influence on cognitive functions (cf. Weyerer et al., 2010, pp. 1163f.).
With regard to the **region** in which the nursing homes are located (urban or rural) (coding: URB), there are, apart from the study by Zimmermann et al., no confirmed results on influences available. Weiß et al. include this factor in their analysis, but cannot find any significant results with regard

[4] The problem of the measurement system mentioned above is also considered in the study

to the nursing degrees (cf. Weiß et al., 2014, p. 97). They refer to the thesis of Neumann, Klewer and Kugler that rural institutions have less access to sufficiently qualified nursing staff, which is why the fulfilment of quality standards has a higher priority in order not to lose qualified staff (cf. ibid., p. 91). Vice versa, poorer access to personnel can of course also lead to lower quality. This thesis is also to be given preference at this point.

Thus the following configurational model results regarding the question about the organizational influence on the rate of falls:

$$BIG* \sim URB * (\sim HLU + \sim DCU) \rightarrow FALL$$

Excessively high numbers of falls among residents are caused by large facilities outside larger urban areas, where residents do not live in special care units such as HLUs or DCUs.
It is evident that this model is primarily exploratory and hypothetical. The literature is ambiguous with regard to its results and only loosely connected with the chosen outcome. Therefore, this model must be seen as an inductive testing of a personal theory (cf. Jordan et al., 2011, p. 1162) rather than a literature-based deduction.

5.2 Calibration

All following operations will be carried out with the R package “QCA” (Duşa, 2020). The respective code that is used is set in boxes.

Conditions

1. Size of facility

To date there is no theoretically uniform way of categorizing nursing homes as “small” or “large”. In order to justify the calibration, statistical data about the distribution of the classes of sizes of German nursing homes will be used. DESTATIS, the federal statistical office, releases the “Pflegestatistik”, a collection of statistics concerning multiple aspects of nursing care like amount of residents/patients, staff and sizes of facilities.
By choosing 20 beds as the point for full exclusion from the set of big nursing homes and 100 for full inclusion, 12,5% (exclusion) resp. 17,1% (inclusion) of the German nursing homes are subsumed at each end of the spectrum (cf. Destatis, 2018, p. 32). In June 2018 three quarters of all German nursing homes were calculated to have between 21 and 110 beds (cf. Ströder et al., 2018, p. 9). By choosing these values it is assured that the condition is calibrated according to sizes of nursing homes in the empiricism.
Regardless of the two ways to calibrate in- and exclusion points (model 1: e = 20, i = 100; model 2: e = 21, i = 110), the fuzzy values stay rather stable with a mean change of only 2,4 points over all cases. To be based on reliable, federal data, model 1 is chosen.
For the qualitative anchor, the average amount of residents living in a German nursing homes was chosen. In lack of a more substantive classification, this is seen as the factor, that is most usefull to represent the entirety of German nursing homes. The most recent “Pflegestatistik” from 2017 reports an average of 64 beds (cf. Destatis, 2018, p. 32). Since this is also the period in which the data collection took place, it is a suitable reference for calibration.
Older data from 2013/2014 report an average of 69 beds (cf. N.N., 2018, p. 11). For comparison both values are used for a direct calibration:

```
QCAModel$BIGhigh <- calibrate(QCAModel$BED, type = "fuzzy",
+ thresholds = "e=20, c=69, i=100")
QCAModel$BIGlow <- calibrate(QCAModel$BED, type = "fuzzy",
+ thresholds = "e=20, c=64, i=100")
```

```
mean(QCAModel$BIGlow-QCAModel$BIGhigh)
Output:
0.03432349
```

By employing the two different calibration thresholds and comparing the mean of the resulting fuzzy values, it can be seen, that they change by an average of 3,4 points over all cases.
To find out which cases are affected in a qualitative way, the cases with fuzzy values over 0,5 in each column are filtered are compared:

```
setdiff(filter(QCAModel, BIGlow >= 0.5),filter(QCAModel, BIGhigh >= 0.5)) %>% .$ID
Output:
"48-01" "48-02" "48-03"
```

With a qualitative anchor of 64 beds, nursing home #48 changes its qualitative state from **not belonging** to the set of big facilities, to **belonging** to it. With a total of 65 beds, this facility lies close to the edge of the chosen calibration. All other cases remain on their respective side of the anchor. Even though the changes are maginal, the more recent data is chosen.
Again it is to be noticed, that the usage of external data is strongly advised. Plotting the number of residents (see diagram 5.1, dotted lines are the points for full in- and exclusion) and adding the mean value of the collected data (76,7; purple line) and the mean value of Germany (red line), it can be seen, that a whole lot more cases change their respective qualitative state. This much higher value, however, is not representative for the sum of all facilitys. The mean value is also problematical, because it is drawn at a point of the data where a lot of cases lie in the range of only two beds above or below. This makes the calibration especially vulnerable to even slight changes.
The QCA package for R has a function, that finds thresholds on the base of cluster analysis. When employing this function, 81 is chosen (blue line). Again, this is solely a calculation based on the observed data and would lead to the false conclusion that entirety of nursing homes in German is much larger.

2. Region: Urban/Rural

In accordance with Zimmermann et al., 2019[5] and the employed seperation the PiBaWü-study used, the threshold for the change from an rural to urban location of a nursing home can bet set to 20.000 inhabitants in the community the facility is located in. By German law, this is the point where a community is no longer a small town but medium-sized. More precisely, the Bundesamt

[5] Jaroslava Zimmermann provided the used threshold in a personal correspondence.

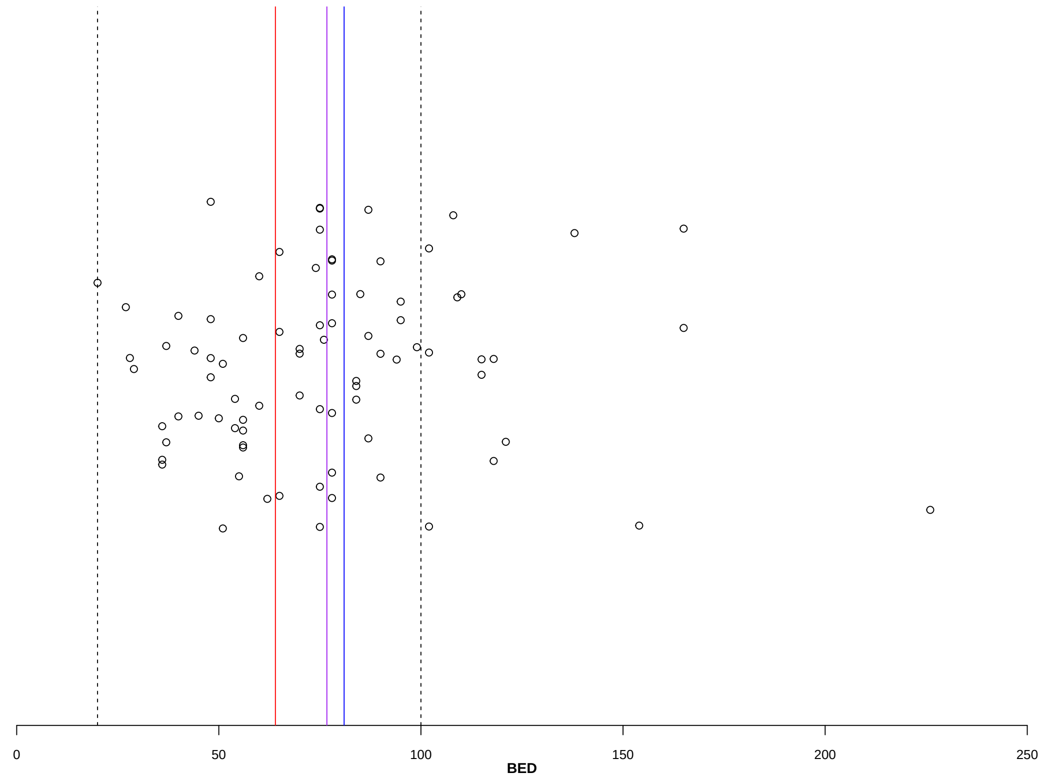


Figure 5.1: X Plot for number of beds

für Bauwesen und Raumordnung[6] speaks of a "kleine Mittelstadt[7] [8]".
Since the German law has a very elaborate way of structuring the types of communities and cities and the data is rather heterogeneous, it might be a shortcoming to calibrate them as crisp sets. The range of inhabitants expands from approx. 900 to well over 600.000. Since the configurational model expects that smaller nursing homes in rural regions have different effects on their residents outcomes, much of the underlying diversity could be lost by treating the influence of 2000-people village the same as a 19.500-people town.
Therefor the original binary values were discarded and a new condition was constructed based on the mailing addresses of the participants. By means of them, the number of inhabitants was determined. Then the classification in table 5.2 that is based on the official, German system was employed.
By choosing 4999 as point of full exclusion and 99.999 as point of full inclusion in the set of urban regions, a direct calibration can be performed. The qualitative anchor remains the same as for the crisp calibration.

3. Home-like care units

The calibration of home-like care units is only reasonable as crisp-set. A graduated classification in an ordinal way of "more home-like than..." doesn't appear to make sense. Since there is no consensus about the criteria that have to be fulfilled to be officially treated as a home-like care unit

[6] Federal Office for Building and Regional Planning
[7] small medium-sized town
[8] `https://www.bbsr.bund.de/BBSR/DE/forschung/raumbeobachtung/Raumabgrenzungen/deutschland/gemeinden/StadtGemeindetyp/StadtGemeindetyp.html?nn=2544954`

Table 5.2: Classification of German communities by number of inhabitants

Name	No. of inhabitants
Landgemeinde (rural community)	<5000
kleine Kleinstadt (small small-town)	<10.000
große Kleinstadt (large small-town)	<20.000
Mittelstadt (medium-sized town)	<100.000
Großstadt (large city)	>= 100.000

(cf. Gray and Farrah, 2013, p. 4), different nursing homes subsume a number of concepts, ideas and ways of working under this expression. In PiBaWü it was therefore left to the participating facilities, if they defined their respective units as "home-like" or not. The limiting factor was, that there had to be a specific concept for these kind of units. A subsequent possibility to manipulate this calibration is therefore not given.

4. Dementia care units

Like home-like care units, only a crisp calibration is justifiable. The condition was to be coded by the study participants with "1" if the nursing home had a separate unit that was reserved for people with dementia and if this unit had a specific concept of care. Here too, a subsequent possibility to change this calibration is not given.

Outcome

Rate of falls

For the outcome it has to be defined at which point one has to speak of a **high** rate of falls, that exceeds the "normal" amount of residents suffering from serious fall consequences. The PiBaWü study used the system by Wingenfeld et al. (Wingenfeld et al., 2011) to assess the number of falls with serious consequences. Residents had to suffer one or multiple of the following conditions: consistent pain, treatment requiring wounds, fracture or increased need for help with everyday tasks or mobility. When at least one of these applied, the fall was counted. For every case, each represents a care unit in a nursing home, a rate of falls was constructed. For this purpose the amount of people who suffered at least one fall over the time of six month, in which the data collection for quality measures took place, were divided by the total amount of residents living in the respective unit. This equates to a cumulated incidence of falls (cf. Balzer et al., 2013, p. 13).
Lahmann et al. conducted a comprehensive study from 2006 to 2013 that assessed, among other things, the amount of falls in German nursing homes (Lahmann et al., 2014). They reported an annual rate of falls ranging from 3,8% (2007) to over 6% (2011), resulting in an over all average of 4,6% (cf. Lahmann et al., 2014, p. 654). Their data is based on 17-76 nursing homes per year providing data of a total of 25.382 residents (cf. ibid., p. 653). A limiting factor for the usage of this value is the situation, that even though they also divided the falls by seriousness of consequences,

it is not possible to match the factors in a fully identical way.
Because of this, a second study was consulted. This one was conducted by Wingenfeld in 2014 using the same classification for falls (cf. Wingenfeld et al., 2014, p. 11). He collected data from 23 nursing homes in North Rhine-Westphalia, providing 8.286 resident datasets (cf. ibid., p. 17). The study evaluated the influence of a certificate for facilities with special engagement in reducing falls. The resulting rates of fall where distinguished into residents with and without cognitive impairment and those living in a certified facility and those who did not. They ranged from an average of 8.7% (no cognitive impairment - no certified nursing home) to 10.2% (cognitive impairment - regardless of nursing home) (cf. ibid., p. 18). With the choosing of 9.4%, the rate of falls for non impaired residents in the intervention group, one has a good middle way within that range.
To get a better understandig of the influence of a qualitative anchor that is twice a high as the other, similar computations were performed than with the first condition. The raw data was directly calibrated for high rates of fall, using the three points: e = 0.01, i = 0.15 and c_1 = 0.046 (*FALLres* = restrictive threshold)/ c_2 = 0.094 (*FALLrel* = relaxed threshold). The results of an older study by Kottner, Dassen and Heinze from 2010 in 76 nursing homes suggests, that an exclusion point of 15% of falls can be suitable to determine a rate of falls as unusually high (cf. Kottner et al., 2010, p. e101). The threshold for unusually low rates is set to 1%.

```
QCAModel$FALLrel <- calibrate(QCAModel$FALL, type = "fuzzy", thresholds = "e=0.01, c=0.094, i=0.15")
QCAModel$FALLres <- calibrate(QCAModel$FALL, type = "fuzzy", thresholds = "e=0.01, c=0.046, i=0.15")
```

```
mean((QCAModel$FALLres-QCAModel$FALLrel))
```

Output:

0.07525934

By employing the two different calibration thresholds and comparing the resulting fuzzy values, it can be seen, that they change by an average of 7,5 points over all cases.

```
setdiff(filter(QCAModel, FALLres >= 0.5),filter(QCAModel, FALLrel >= 0.5)) %>% .$ID
```

Output:

"02-01" "02-02" "03-01" "07-02" "11-01" "20-01" "23-01" "33-02" "48-02" "52-02" "55-02"

With the change of the calibration several nursing homes change their qualitative state. While in most of the facilities, where there is data for more than one care unit, all units change their state, in number 11, 48 and 55 only one unit passes the qualitative anchor.

- units of facility 11: -01 = rate of falls: 8%; -02 = rate of falls: 4% (other conditions are identical)

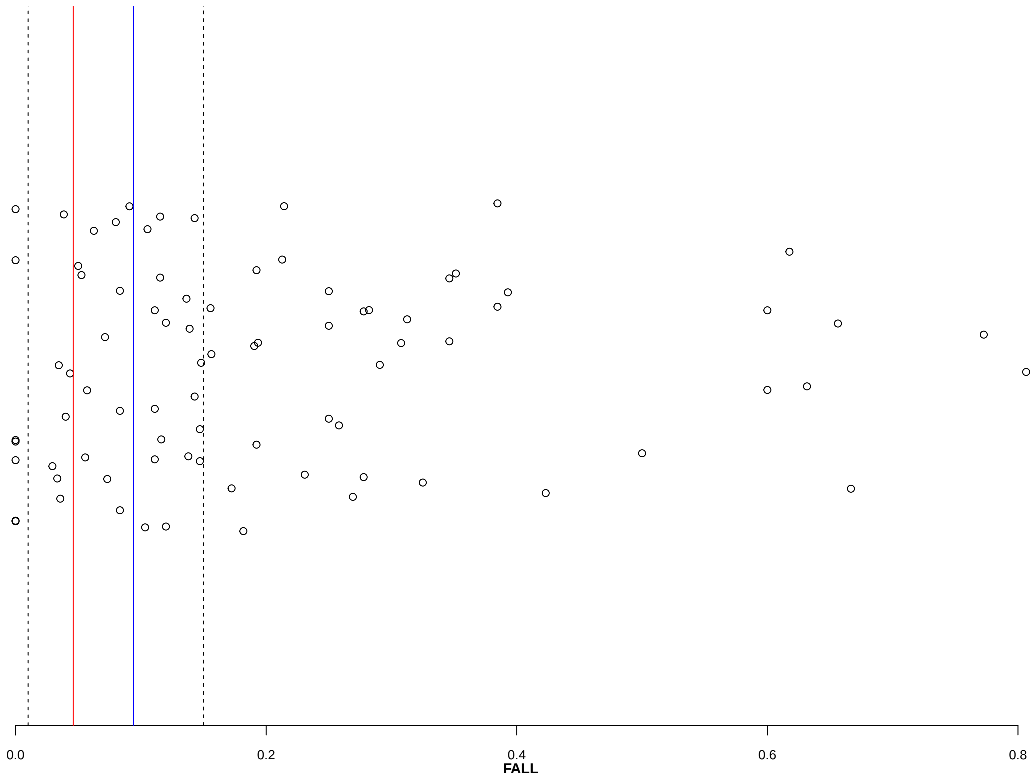


Figure 5.2: Rate of falls with different qualitative anchors

- units of facility 48: -01 = rate of falls: 31%; -02 = rate of falls: 5% (other conditions are identical)

- units of facility 55: -01 = rate of falls: 31% and DCU; -02 = rate of falls: 7%; -03 = rate of falls: 4%

Taking a closer look at the individual conditions, it can be seen that in nursing home 11 and 48 only the rate of falls differs. In the case of #48-01 and #48-02 even by the factor 6,2. With 8% in #11-01 and 5% in #48-02 they lie on the edge of the calibration thresholds, making them vulnerable to relatively small changes. The respective other units each lie too far above or below the threshold values to be affected by the employed changes. All other conditions are identical over those cases. Units #55-02 and #55-03 also differ significantly in their rate of falls with unit 3 below the lower anchor to be affected by changes. In this case, unit 1 is a DCU with a very high rate of falls (31%). Plot 5.2 shows, how the qualitative position of different cases in the set of high rates of falls changes with the application of the two thresholds (red = c_1, blue = c_2). Since both are justifiable, two analyses will be run to compare the results in light of the robustness of the findings of each. Table 5.3 contains all conditions with their respective calibration thresholds.

Table 5.3: Calibration of conditions

Name	**Code**	**Type**	**full exclusion**	**qualitative anchor**	**full inclusion**
Size of facility	*BIG*	direct	20	64	100
Region	*URB*	direct	4999	19.999	99.999

Home-like care unit	HLU	crisp		specific concept	
Dementia care unit	DCU	crisp		specific concept + separate unit	
Rate of falls	$FALLres$	direct	0.01	0.046	0.15
Rate of falls	$FALLrel$	direct	0.01	0.094	0.15

5.3 Sample

As described the data stems from the PiBaWü-study. Since data collection was performed on different levels, a specific data frame for the QCA was constructed. The outcome was assessed on the level of residents. Since the research question focuses on organizations, the individual fall events of the residents were aggregated in rates of falls. Since it is expected that living in different units affects the outcome, the nursing homes can not be treated as one single entity. Residents were therefore assigned to their respective care units within the facility where also information about the type of unit (dementia care unit, home-like care unit or regular care unit) was available. Information about the region and the size were collected on level of the whole nursing home and broken down to unit level.

Not for every nursing there is data available for several units. This is due to fact that not every facility had more than one unit. In other cases, nursing homes only participated with a sample of their units. This sample was randomly drawn. Since not all data collection tables were returned consistently and/or could be completed in follow-up contacts, certain cases with missing values had to be eliminated. This results in a raw data table with 83 cases of 57 nursing homes.

The participating facilities themselves are a convenience sample from all inpatient nursing homes in Baden-Württemberg. Since very little is known about the research topic and it is an exploratory approach, as many cases as possible were included into the sample to catch the most empirical diversity.

5.4 Truth tables

With the different, employed calibrations, two different analysis models result:
Model 1: $BIG, URB, HLU, DCU \rightarrow FALLrel$
Model 2: $BIG, URB, HLU, DCU \rightarrow FALLres$
For each one, a truth table is generated:

```
truthTable(QCAModel, outcome = "FALLrel", conditions = "HLU, DCU,URB,BIG", incl.cut = 0.85, n.cut = 3, pri.cut = 0.75)
truthTable(QCAModel, outcome = "FALLres", conditions = "HLU, DCU,URB,BIG", incl.cut = 0.85, n.cut = 3, pri.cut = 0.75)
```

The inclusion cut-off/consistency threshold is set to a relatively high value of 0.85 to generate profound solutions. The threshold for the proportional reduction in inconsistency (PRI) ist set to 0.75. Since all configurations that pass the consistency value surpass this threshold, it could have been also set higher. With a total of 83 cases, a frequency cut-off should be set. After a first analysis, at least 3 cases were chosen to be necessary for a configuration to be considered as consistent. This is also in accordance with the literature (see section 3.3.5). The PRI cut-off was set to 0.75, but was in no instance the single reason to exclude a configuration from the sufficiency statement. Inclusion and/or frequency values also spoke against sufficiency. The full truth tables are attached in the appendix (see section 3.3.4).

It can be seen, that there are some more or less significant changes in the consistency scores, depending on the calibration of the outcome and URB. However, over all analyses the remainder

rows the same (5, 7, 10, 11, 13, 14 ,15). For $Fallrel$, the rows 1, 2, 4 ,6 and 12 are coded negative for the outcome due to too low consistency values. Whereas for $FALLres$ also rows 2 und 4 pass the inclusion threshold. This is due to the more fine grained differentiation in degree.
Column "DCC" shows the deviating cases, that contradict sufficiency in the respective row of the truth table. It can be seen, that $FALLres$ produced considerably less contradictions than $FALLrel$, which speaks for a better calibration.
Configurations 4 ($\sim DCU, \sim HLU, URB, BIG$) and 2 ($\sim DCU, \sim HLU, \sim URB, BIG$) for outcome $FALLrel$ have 7 resp. 3 deviating cases. For #4 this is no wonder, since it is the highest populated row with $n = 20$. Chances are simply higher to produce more contradictions. #2 in contrast only has 8 cases but 3 deviating cases: 28-02, 33-02 and 48-02.
When using the stricter calibration for the rate of falls, the amount of contradictions for configuration 4 drops to only 3 for $n = 20$, configuration 2 only has a single deviating case with its n remaining at eight cases. Configuration 1 is the least consistent one over all analyses (incl = 0.571 - 0.772). Since it contains the absence of all four conditions and therefore no organizational influence is tested, no clear tendency towards an expression of the outcome is shown. Here, too, the number of deviating cases is reduced clearly with $FALLres$ as outcome (from 9 to 5).
Over all, the amount of contradictory cases per row is manageable, especially with contradictions being the rule rather than the exception. And since no theoretically meaningful configurations are affected by large amounts of deviating cases and theory is already scarce, the "treatment" is reduced to an inclusion cut-off.

5.5 Necessary conditions

An analysis of all possible necessary conditions and their conjunctions and disjunctions via superSubset()-command was conducted

```
superSubset(QCAModel,outcome = "FALLrel", conditions = c("BIG","URB","HLU","DCU"), incl.cut = 0.95, cov.cut = 0.5)
superSubset(QCAModel,outcome = "FALLres", conditions = c("BIG","URB","HLU","DCU"), incl.cut = 0.95, cov.cut = 0.5)
```

The inclusion cut-of was set relatively high, since no false conclusions should be drawn about such a significant aspect as necessity. For the sake of demonstration, a lower coverage cut-off and relevance of necessity (RoN) treshold was used. Table 8.4 in the appendix shows the respective results. It can be seen that there are plenty of conjunctions, that pass the consistency threshold and show values up to 0.988. The coverage values for the conjuctions in the outcome $FALLrel$ lie around 0.71, for $FALLres$ they circle around 0.78. This is not perfect but would be enough to consider them as necessary.
Software like fsqca 3.0 by Ragin provides no further parameters than the coverage. By examining the RoN values provided by the QCA R package it becomes clear, that none of the found paths can be considered as necessary. Only two conjunctions exceed a value of 0.2 which makes an interpretation redundant. This shows the importance of a full examination of all recently available parameters of fit.
A cautious "interpretation" of the results can still be made: The fact that only conjunctions of at

least three conditions show high inclusion values, supports the thesis that the phenomenon under investigation is a truly **complex** one, where no simple solutions are available (cf. Duşa, 2020, p. 130). The decision to use a method that is capable of handling complexity has proven to be reasonable.

5.6 Solutions

Conservative solution

```
con <- minimize(TT, details = TRUE)
con2 <- minimize(TT2, details = TRUE)
```

For the **first truth table**, three sufficient paths are found that lead to a higher rate of falls:

DCU*URB*BIG + ∼HLU*∼DCU*URB*∼BIG + HLU*∼DCU*∼URB*∼BIG → FALLrel

Inclusion and PRI scores for each path are high (incl = 0.887 - 0.936, PRI = 0.808 - 0.96), but both coverages, solution and unique, are very low, ranging from 0.095 to 0.177.
When using $FALLres$ in the **second model**, the additional truth table rows 2 and 4 can be used to eliminate $\sim BIG$ from path 2 of model 1 and also finding an additional path:

∼HLU*∼DCU*URB + ∼HLU*∼DCU*BIG + DCU*URB*BIG + HLU*∼DCU*∼URB*∼BIG → FALLres

The parameters of fit indicate a rather reliable solution and with a value of 0.636 the solution coverage is decent. Unfortunately the unique coverages are much lower than in model 1.
When exemplarily examining the XY-plots (see figures 8.1 and 8.2 in the appendix), it can be seen, that in the first a lesser amount of cases lie beneath the main diagonal and therefore **not** in the sufficiency area. For model 2, the amount of cases is much higher and many of them lie significantly farther away from the diagonal. Even though the inclusion rate is not too different, model 1 presents a better model in terms of the distribution of the cases. Then again, there the coverage is nearly only half as high as in model 2. So, a trade-off will have to be made, when choosing the "best" model.

Parsimonious solution

As explained in section 3.3.5, simply using all available remainders for the minimization will lead to the risk of including difficult counterfactuals. Just like throwing every ingredient available in your kitchen in one pot doesn't produce a tasty meal (cf. Duşa, 2020, p. 185). Therefor the "pure" parsimonious solutions (cf. ibid., p. 196) can not serve as a basis for the interpretation.
By minimizing the first truth table with all remainder rows (5,7,10,11,13,14,15) two shorter solution terms are found:

M1: DCU*URB + URB*∼BIG + (HLU*∼URB) →FALLrel

M2: DCU*URB + URB*∼BIG + (HLU*∼BIG) → FALLrel

It would be tempting to simply use these and interpret them. However, when examining the incorporated simplifying assumptions, the downside of this procedure becomes clear:

```
par <- minimize(TT, include="?", details = TRUE)
par$SA
```

Output:

M1

	HLU	DCU	URB	BIG
7	0	1	1	0
10	**1**	**0**	**0**	**1**
11	1	0	1	0
13	1	1	0	0
14	**1**	**1**	**0**	**1**
15	1	1	1	0

M2

	HLU	DCU	URB	BIG
7	0	1	1	0
11	1	0	1	0
13	1	1	0	0
15	1	1	1	0

Both solutions use several configurations that are contrary to the theoretical expectancy which deems *BIG* responsible for the production of the outcome and the other conditions for the non-presence and not vice versa. Only rows 10 and 14 can by any means be good counterfactuals.
By minimizing truth table 2 with all remainders even 10 different solutions from 8 terms are derived, that each incorporate difficult counterfactuals (see table 8.8 in the appendix).
Since thoughtless parsimony can not be a way of infering scientifically rich solutions, it will be refrained from discussing these types of results here. They are solely reported for the sake of completeness and definition of core and contributory conditions in the presentation.

Intermediate solution

By applying directional expectancies into the minimization process, these difficult counterfactuals can be barred from being used in the minimization process. By defining the command as follows:

```
inter <- minimize(TT, include = "?", dir.exp = "BIG", details = TRUE)
```

we expect the condition *BIG* to be present whenever the outcome occures. For the **first model** the resulting solutions are:

M1: HLU*∼ DCU* ∼ URB + DCU*URB*BIG +∼ HLU*∼ DCU*URB*∼ BIG → FALLrel
M2: DCU*URB*BIG + ∼ HLU*∼ DCU*URB*∼ BIG + HLU*∼ DCU*∼ URB*∼ BIG → FALLrel

with M2 being identical to the conservative solution.
When checking for the applied counterfactuals, it can be seen, that only row 10 is used as an easy counterfactual (EC), the rest of the rows is excluded as difficult counterfactuals (DC). M2 uses no remainders, which explains the equality with the conservative solution.

inter$i.sol$C1P1$EC
inter$i.sol$C1P1$DC
inter$i.sol$C1P2$EC

Output:

M1

EC

	HLU	**DCU**	**URB**	**BIG**
10	1	0	0	1

DC

	HLU	**DCU**	**URB**	**BIG**
7	0	1	1	0
11	1	0	1	0
13	1	1	0	0
14	1	1	0	1
15	1	1	1	0

M2

EC

<0 rows>

Minimizing **truth table 2** with the same directional expectancy leads to three different solutions:

M1: ~HLU*~DCU*URB + HLU*~DCU*~URB + DCU*URB*BIG + (~HLU*~DCU*BIG) → FALLres

M2: ~HLU*~DCU*URB + HLU*~DCU*~URB + DCU*URB*BIG + (~DCU*~URB*BIG) → FALLres

M3: ~HLU*~DCU*URB + ~HLU*~DCU*BIG + DCU*URB*BIG + HLU*~DCU*~URB* BIG → FALLres

M1 and M2 both use row 10 for minimization and differ only in the term in parentheses. M3 doesn't use remainders which makes the solution identical to the conservative one.

In conclusion, the QCA leads to the solutions presented in table 5.4. Due to the scarce theoretical foundation, it is refrained from using more exhaustive directional expectancies.

A common problem in QCA, the simultaneous use of truth table rows for the mimimization of the outcome and its negation, isn't present in this analysis. By examining the truth tables for $\sim FALLrel$ and $\sim FALLres$ (see table 8.6 in the appendix) it can be seen, that no row can be considered to be sufficient for the outcome. Inclusion and PRI scores are much to low. So incorporating row 10 can not lead to a **contradictory assumption**. Since no necessary conditions could be found, there is also no problem with counterfactuals that **contradict the statement of necessity**.

Table 5.4: Overview of all solutions

	Outcome = FALLrel
Conservative	DCU*URB*BIG + ~HLU*~DCU*URB*~BIG + HLU*~DCU*~URB*~BIG
Intermediate	HLU*~ DCU* ~ URB + DCU*URB*BIG +~ HLU*~ DCU*URB*~ BIG
Parsimonious	DCU*URB + URB*~BIG + (HLU*~URB)
	DCU*URB + URB*~BIG + (HLU*~BIG)
	Outcome = FALLres
Conservative	~HLU*~DCU*URB + ~HLU*~DCU*BIG + DCU*URB*BIG + HLU*~DCU*~URB*~BIG
Intermediate	~HLU*~DCU*URB + HLU*~DCU*~URB + DCU*URB*BIG + (~HLU*~DCU*BIG)
	~HLU*~DCU*URB + HLU*~DCU*~URB + DCU*URB*BIG + (~DCU*~URB*BIG)
Parsimonious	~HLU*URB + HLU*DCU + HLU*~URB + ~HLU*~DCU*BIG
	~HLU*URB + HLU*DCU + HLU*~URB + ~DCU*~URB*BIG
	~HLU*URB + HLU*DCU + HLU*~BIG + ~HLU*~DCU*BIG
	~HLU*URB + HLU*DCU + HLU*~BIG + ~DCU*~URB*BIG
	~HLU*URB + HLU*~URB + DCU*URB + ~HLU*~DCU*BIG
	~HLU*URB + HLU*~URB + DCU*URB + ~DCU*~URB*BIG
	~HLU*URB + HLU*~BIG + DCU*URB + ~HLU*~DCU*BIG
	~HLU*URB + HLU*~BIG + DCU*URB + ~DCU*~URB*BIG
	HLU*~URB + DCU*URB + URB*~BIG + ~HLU*~DCU*BIG
	HLU*~BIG + DCU*URB + URB*~BIG + ~HLU*~DCU*BIG

5.7 Robustness

Before continuing to the discussion of the results, several robustness tests should be conducted.
The suggested **change of the calibration threshold**, using other justifiable points has already been done to some extent in the calibration section. Where possible, changes led to no significant altering in the partition of the sets. The robustness ranges proposed by Tore Hofstad are now implemented as "calibration ranges" in the R package SetMethods (`https://CRAN.R-project.org/package=SetMethods`), unfortunately without direct reference to Hofstad's work (Hofstad, 2019). Table 5.5 shows the upper and lower bonds for the two fuzzy conditions of the configurational model at 10 interations each with the corresponding steps, where the intermediate solutions remain identical. "NA" stands for instances in which no change could be detected with the steps and iterations used. Starting point is always the calibration described in chapter 5.2. It can be seen that the selected values are relatively robust and can withstand changes of 7-8% even at the weakest points.

Table 5.5: robustness range

		Bond	Anchors			Steps
			Exclusion	**Crossover**	**Inclusion**	
FALLrel	**BIG**	Lower	NA	59	70	5
		Upper	55	69	120	
	URB	Lower	NA	16.000	NA	500
		Upper	NA	22.000	NA	
FALLres	**BIG**	Lower	NA	59	75	5
		Upper	60	69	110	
	URB	Lower	NA	NA	NA	500
		Upper	NA	22.000	NA	

Proportional removal of cases is one way to test, if a solution is highly relying upon certain cases to produce a solution, or if it is rather stable in findings. To test this, 5% of the cases were randomly removed from the truth table and a new solution was calculated. This was done three times for each model. As can be seen in table 5.6, the conservative solution of model 1 was reproduced in 2 of 3 instances. For model 2's solution this is only the case on time (for full results see tables 8.10 and 8.11 in the appendix).

For changing the **frequency threshold**, the resulting conservative solutions were examined when moving the cut-off from 3 to 2 respectively 4. Tables 8.12 and 8.13 in the appendix show the changes. A complete replication of every configuration is not given for any instance. Only the increase to n = 4 in model 2 creates a nearly identical solution with only a small change from DCU*URB*BIG to ∼HLU*URB*BIG in configuration 3. Most stable is solution path HLU*∼DCU*∼URB*∼BIG. It is reproduced in both altered analyses for this outcome.
Since in both original truth tables there are 3 rows with n = 2 and 2 rows with n = 3, it is altogether not surprising that certain changes occur. Decreasing the cut-off means, that you increase the

Table 5.6: Overview of results from proportional removal

Removed rows	Obtained conservative solution
Model 1	
13, 47, 62, 75	identical
21, 23, 32, 41	identical
24, 28, 39, 45	divergent
Model 2	
13, 47, 62, 75	divergent
21, 23, 32, 41	identical
24, 28, 39, 45	divergent

amount of truth table rows available for minimization by 75% and vice versa decrease it by 25% when raising the threshold. Even though this QCA uses 83 cases, some rows of the truth table are scarcely occupied, one is empty. As explained before, this is normal due to "natural" clustering of configurations. Nevertheless, it decreases, or at least influences, the stability of the found solution.

5.8 Presentation

FALLrel

The consistency values of all three solution paths show good consistency and PRI values (>.800). The solution is robust in this respect. Also the proportional removal of casesn shows, that the solution is relatively stable and not just based on single cases. When faced with threshold variations and the resulting occupation of the truth table, however, instabilities become visible. Nevertheless an overall sufficiently robust solution can be assumed.

For all paths, the coverage value is rather low. The individual terms of the solutions only have values between 0.120 - 0.177. None of the paths therefore has an outstanding, individual empirical importance. Despite this low coverage, it can be seen that each path covers a different area of the outcome, as the unique coverage corresponds to the raw coverage. All three together cover 41% of the cases of the sample. This value indicates that conditions that form the outcome are not yet included. The chosen organizational factors, on the other hand, are nevertheless strong clues.

Every configuration makes statements about at least one form of care unit. M1-1 and M1-2 identify the presence of a HLU or DCU as a necessary prerequisite, which contradicts the theory put forward above. Only M1-3 is in line with the expectations that the absence of both specialized forms of housing will increase fall rates. However, this path is empirically the most irrelevant and only occupied with 4 cases. The urban situation plays a major role for the two paths M1-2 and -3 and is a core condition. In contrast to the established theory, falls occur more frequently in urban facilities. The expectation, that large facilities have a reinforcing effect on the outcome can be only found in M1-2, in which, however, the factor is also only used as a contributory condition. M1-3 sees URB as a core condition for an increased rate of falls.

To couch the solution in terms: Falls are more likely to occur where residents...

(1.)...live in home-like structures instead of dementia care units and not in urban regions (M1-1),

(2.)...live in dementia care units of a large urban facility (M1-2), or

(3.)...neither live in a DCU nor in a HLU of a small, urban facility.

The individual paths are therefore very different from each other.

FALLres
Here, too, the consistency and PRI values speak for good to very good solutions. However, they are somewhat more susceptible to the robustness checks performed. The two solutions M1 and M2 differ only in their last term M1-4 an M2-4. The two middle terms DCU*URB*BIG and HLU*∼DCU*∼URB are equivalent to M1-1 and -2 of the first solutions with differently calibrated outcome. This indicates that they are particularly robust. The respective coverage values are comparable to those from the FALLrel solution. The raw coverages for the newly added paths are with 0.225-0.356 clearly higher than in the first analysis, resulting in a solution coverage of 0.665 and 0.654. However, the unique coverages show, that these very paths overlap very strongly with the others. With only 3-9% coverage of the sample, they play a very limited, individual role. Only M2-1 shows a significantly higher value of 0.202 and thus also has the highest unique coverage of all solution paths.
Also for FALLres there are no clear statements regarding the influence of the care units. Both their presence and absence can be sufficient conditions for the occurrence of the outcome. In this second analysis, however, large facilities form a partial reason for an increased fall rate (M1/2-3 and -4). However, the results don't offer a clear picture. The theory set out above is not tenable in this light. Put in text the results mean that higher rates of fall occure in nursing homes that...
(1.)...are big, no matter if they are urban or not and residents live or live not in a DCU (M1/2-3 and M2-4),
(2.)...are big and the residents don't live in a specialized care unit (M1-4),
(3.)...are organized home-like in a non-urban area, where residents don't live in a DCU (M1/2-2), or
(4.)...are urban and the residents don't live in a specialized care unit (M1/2-1).

The solutions draw a very different picture for the research question posed. The two most robust paths are HLU*∼DCU*∼URB and DCU*URB*BIG. They can be found in all three solutions, have high raw consistency and PRI scores and, within the generally low raw coverage, have a high percentage of unique coverage. Nevertheless, high **model ambiguity** is present. The coverage values are clearly related to the fact that only organizational factors are considered. This can be explained by the high complexity of the subject. The view on the fall rate is under the focus of organizational factors and is therefore limited. As an example, it can be shown very clearly that the chosen conditions have a robust influence on the outcome, even if not in the expected configurations.

FALLrel				FALLres							
		M1			M1				M2		
configuration	1	2	3	1	2	3	4	1	2	3	4
HLU	●		⊗	⨂	●		⨂	⨂	●		
DCU	⊗	●	⊗	⨂	⨂	●	⨂	⨂	⨂	●	⨂
URB	⨂	●	●	●	⨂	●		●	⨂	●	⨂
BIG		•	⨂			●	●			●	●
raw consistency	0.855	0.936	0.887	0.864	0.899	0.954	0.839	0.864	0.899	0.954	0.878
PRI score	0.833	0.930	0.808	0.829	0.890	0.949	0.795	0.829	0.890	0.949	0.822
raw coverage	0.120	0.177	0.117	0.295	0.144	0.163	0.356	0.295	0.144	0.163	0.225
unique coverage	0.120	0.177	0.117	0.032	0.114	0.163	0.093	0.202	0.065	0.163	0.083
solution consistency		**0.897**				**0.872**				**0.883**	
solution coverage		**0.414**				**0.665**				**0.654**	

Figure 5.3: Fiss chart for intermediate solutions

Chapter 6

Discussion

Concluding, various points raised in the work are to be discussed. For the sake of clarity, this is done separately according to the areas of concrete application of the QCA to the PiBaWü dataset and the discussion about the QCA as a method itself.

6.1 Discussion of the application

The **configurational model** is based only on weak assumptions. The study situation on this topic is very poor and more comprehensive theories do not exist at present. The influence of organizational factors on resident outcomes is an area that has received very little attention so far and for which there is little knowledge, especially in Germany. With the outcome "fall", a phenomenon has already been chosen whose causes have been investigated very comprehensively and which is a frequently discussed topic in literature and practice. Nevertheless, virtually no studies or substantial evidence could be found on the causes of falls that go beyond resident-intrinsic factors. The situation is significantly worse with less prominent outcomes.

The **selection of conditions** is mainly based on the study and doctoral thesis of Jaroslava Zimmermann (cf. Zimmermann et al., 2019, Zimmermann, 2019). Her selection of influencing factors is also based on weak assumptions: The factors used for a regression result from the literature research, which does not specifically refer to falls. For lack of reliable findings, any influence of organizational features on the resident outcomes was taken as an indicator. Furthermore, the studies used are largely international and are therefore not directly transferable to the German system.
This basis for the selection of conditions is clearly a weakness of this thesis, but it also reveals a neglect of the entire subject within nursing science: Influences on outcomes that go beyond the characteristics of the staff or residents are only very sparsely investigated in Germany. This offers great opportunities to investigate the fundamental influence of organizational characteristics, which has in this thesis been proven to exist, more comprehensively.
In order to be able to work more profoundly with the QCA in the future in areas that have hardly been dealt with so far, it would also be conceivable to carry out smaller investigations in advance (see also section 6.2).

The **conditions** "dementia care unit" and especially "home-like unit" can be discussed in terms of their homogeneity across cases. In both cases PiBaWü had not given any concrete content requirements that had to be fulfilled in order for the study participants to declare this as present for their institutions. This inevitably leads to the fact that there are certain bandwidths within which the concrete manifestation moves. This is also related to the fact that there is no uniform, legal definition for these forms of care units to date.
However, the assumption is that if care units in a nursing home describe themselves as one of these forms, this is also reflected in their actions. In order to capture the greatest possible empirical

diversity of a less discriminating construct, the definition has therefore been left rather open.

PiBaWü is **not designed** to analyze the data using QCA. This idea only emerged over time in order to take into account the special features of nursing homes (average number of cases, causal complexity, etc.). If QCA is considered not only as an analysis technique but also as a research approach, this point could be improved. It makes more sense to specifically collect the data necessary for QCA based on theoretical preliminary considerations. In this thesis a compromise had to be found between the existing data and the conditions that would be important for the analysis.

The **participating facilities** of the study are a convenience sample from all fully-inpatient geriatric care facilities in Baden-Württemberg. In the case of partial data collection within one facility, this selection was made as a random sample. In the classical QCA with a small number of cases a conscious construction of the sample is required (cf. Ragin, 2000, chapter 2). This is necessary to obtain a wide range of outcome and conditions in order to combine both equality and difference in the analysis within a few cases. Similarities as a necessary prerequisite to make a comparison, differences to depict diversity (cf. Ragin, 2000, ibid. p. 45).
As the number of cases increases, the knowledge of the exact nature of the cases decreases and thus the possibility of making a very conscious selection. This is the consequence of every large-N QCA. The suggestions presented in the literature for case selection in such cases can hardly be transferred to the circumstances of this work. For example, it is proposed to examine the entire theoretically relevant population (cf. Greckhamer et al., 2013, p. 58). This would be the most optimal case, since no diversity is lost in the process. However, for most cases in the social sciences this is utopian. On the one hand, the entirety of a population can often not be recorded at all (e.g. all people with dementia in a federal state). On the other hand, as is the case in the present study, the totality is practically inaccessible. A complete survey of all inpatient facilities inevitably fails because of the willingness of the actors to participate and, moreover, because of the capacities available for data collection. A stratified sample (cf. Greckhamer et al., 2013, ibid.) fails because of insufficient theoretical and practical knowledge about the subject and its connections. Moreover, it inevitably incorporates the subjective weighting of the researcher, which selects elements for stratification as particularly significant. In this case, diversity, which may be crucial for the construction of the solution, is lost. In the same way, a random sample curtails diversity (cf. Greckhamer et al., 2013, p. 59). The approach in this thesis, that all includeable cases (care units without missing values in the selected conditions) were used, allows to use as much as possible all information available in the data regarding the occurence of the outcomes. It is evident that this can also lead to a bias, but after careful consideration it is considered the best alternative.

The same problem exists for the **calibration**: There are few theoretical considerations about the phenomenon. However, statistical evidence can be used here. Although values of central tendency in QCA are often regarded as “ultima ratio”, they are, however, to be justified in the present case, since they refer to the nationwide totality. Both the references to the size of the institution and the size of the corresponding city are based on uniform guidelines and empirical realities. Thus, sample-independent values were used, which reduce possible bias.

In terms of **presentation**, current publications were consulted and different visualizations from different areas were used (cf. Rubinson et al., 2019). The implementation of **robustness checks** basically follows the paper by Roel Rutten (Rutten, 2020) and also use very new forms, designed for the larger amount of cases uses here (cf. Hofstad, 2019, p. 7). The goal was to act as close as possible to the current state-of-the-art.

All participants were extensively **trained in data collection**. In several events, multipliers from each institution were instructed in the use of the data table. In addition, a manual was created which explains for each variable how it is collected, when a condition is considered to be fulfilled, etc. The project team was also available at any time by telephone or in person to answer questions. In some institutions, the data collection of the organizational factors was also carried out in cooperation with a member of the project team. The Excel data table had a built-in plausibility check. In addition, manual checks were carried out after the data had been transmitted. Missing or questionable data was reported back to the institutions and could be supplemented or corrected in many cases. The transfer of the data from the individual tables of the participants into an evaluable file was carried out by means of automatic transfers into hidden evaluation tables and their extraction by means of Excel macros. Wherever possible, the participants were given the option of selecting from a drop-down menu to reduce errors. The selectable text responses were automatically converted into numerical values using the VLOOKUP()-command. These precautions were intended to avoid manual and thus potentially error-prone intervention in the data as far as possible.
Nevertheless, the occurrence of errors in the form of both transmission errors by the researcher and measurement errors by the participants can never be ruled out. As the variable "region" has shown, some participants probably answered it intuitively, without a precise check whether the criterion ($>$ or $<$ 20,000 inhabitants) is fulfilled. In this case, a correction could be made based on the information available. However, this is not the case for the other selected conditions.
In some cases, extremely high numbers of falls from 15 to 38 times were recorded for residents over the six-month survey period. Whether all these falls met the criterion of "severe consequences" is not comprehensible and can be doubted. For some residents, this would mean a weekly or more frequent fall event with wounds requiring treatment, fractures, persistent pain or the like. Although not excluded, this seems rather unlikely. Four such cases with more than 15 falls each are attributable to cases 01-01 and 24-03, three cases to 67-01 and one case each to 19-01, 35-01, 35-03 and 57-01. The quotient formation across all residents of the care units means that such extreme cases are moderated and do not flow directly into the data, but in the event of an incorrect survey they distort the fall rate upwards.

The rather **low coverage** values of the results indicate that there are several other ways to produce the outcomes within the equifinality framework. This is understandable, since no personal conditions are considered in this QCA. However, it is precisely these person-related factors to which most studies can attribute falls. The aim of omitting them was to deliberately focus the investigation on organizational factors. These shortcomings were knowingly accepted and the **result** should therefore not be understood as a try to comprehensively explain rates of falls. They do, indeed, show a problem of mid- to large-N QCA analyses: The resulting 3 (FALLrel) to 5 (FALLres) configurations are not easily to be brought into a pattern where immediate suggestions for nursing practice can be derived from. One extensive way to deal with them could be an in-depth analysis of typical cases for each path in search for latent or undiscovered pattern. This is in turn a research project on its own in terms of time and work. Another way would be the inclusion of more conditions that are person-related. However, this would involve either a complete change of the population from the care units as cases to the residents or an aggregation of resident conditions on the care unit level. This would level out the diversity of the conditions and is therefore not recommended in the eyes of the author.

The QCA carried out here primarily shows that organizational factors **have** an impact and that Qualitative Comparative Analysis **can** be usefully applied in nursing science, even if it involves certain hurdles that will be discussed in the following section.

6.2 Discussion of the method

Qualitative Comparative Analysis as a method is still relatively young compared to other methods that have been in widespread use within the scientific community for decades. A real, method-theoretical treatment can be assumed from about 2000 onwards. It is therefore understandable that now, just two decades later, a more in-depth discussion is only just beginning. Every year not only the practical applications increase, but also the methodological papers that focus on further development. Although QCA is still far from mainstream, it already has a large circle of established users and theorists.
Nursing science is also discovering the QCA as a possible extension for its “methodological toolbox”. In conclusion, we will look again at the extent to which this can be useful for the discipline and what obstacles there are.
A critical discussion of “common” QCA criticisms such as calibration, dichotomization of data, use of remainders or case-sensitivity will not be discussed in detail. These aspects have been treated exhaustively in many publications (Meur et al., 2009, cf., Jordan et al., 2011, pp. 1167ff., Schneider and Wagemann, 2012, pp. 316ff., Kahwati and Kane, 2019, pp. 195ff.) and no substantial addition can be added to them at this point.

Particularly noticeable, however, especially in older publications and “Ragin-related” texts[1] is an overconcentration on the problems of quantitative approaches. Often there is a detailed discussion of the inadequacies of classical, statistical methods, accompanied by an exhaustive defense of QCA against criticisms brought forward by this tradition of analysis (Meur et al., 2009; Ragin, 1987; Miller, 2017; Seawright, 2014; Jordan et al., 2011). Here the origin and development of the method is particularly evident. Ragin postulated the comparative method primarily as a new way to overcome existing problems of qualitative and quantitative methods. By combining qualitative aspects such as theory-guidedness or exhaustive analysis of individual patterns and quantitative abstraction, it should be achieved that “one strategy should check the biases of the other” (Ragin, 1987, p. 70). However, the anchoring lies strongly in the qualitative tradition. In the end, many steps of the execution are based on the choice of parameters by the investigator. Causality does not

[1] Publications that strongly refer to the original works by Charles Ragin or those authors are in close connection with him

result from the data itself, but in connection with substantive arguments. This way of reasoning offers a starting point for criticism for many purely quantitatively-oriented researchers. At the same time, the reference to quantitative elements of the method, such as parameters of fit (consistency, coverage, etc.) is seen as problematic by researchers with a strong qualitative orientation, because this would obscure the fundamental principles of Ragin (cf. Rihoux, 2013, p. 242). One could say that the method is neither fish nor fowl, what would explain the persistent criticism from both research traditions. On the other hand, it must be acknowledged that QCA has laid its own diverging foundation by means of necessary and sufficient conditions, set theory and Boolean algebra, and has developed corresponding best practice methods in order to be able to generate and document results in a comprehensible and methodologically sound manner (cf. Schneider and Wagemann, 2009). The detachment from existing traditions is therefore understandable due to the intention of its development and does not happen without the establishment of new modes of reasoning, which is why it cannot be denied an equal position next to or between the qualitative and quantitative paradigm.

Since the first publications on QCA, the question of how the method is positioned in relation to other (quantitative) methods has also been on the agenda. A very frequent comparison is made between QCA and regressions. However, the views range from complete incompatibility (cf. Misangyi et al., 2016) with each other to the view that both methods can complement each other to deliver better results (cf. Vis, 2012, Fischer et al., 2006).

The widely agreed view is that both methods are used in very different, "causal universes" (p.a Ragin and Pennings, 2005). The premises and assumptions under which causality is assumed and insights are generated differ significantly between the two methods. These different semantics must be taken into account when comparing results. It is questionable whether a weighing up of both methods in the sense of a "better than" makes sense. Both regression and QCA have methodological strengths that they can play out in different fields (cf. Tatarczyk, 2018, p. 51). The underlying assumptions of the one method are no less restrictive than those of the other (cf. Seawright, 2005, p. 5), which makes questions of superiority secondary. Rather, Smithson's view is to be represented here, that "fuzzy sets [and QCA in general] and statistics work better together than seperately" (Smithson, 2016, p. 432). It is much more profitable to combine classical statistical methods with QCA results than to play both off against each other. Thus, investigators can benefit from the combination of epistemological differences (cf. Meuer and Rupietta, 2017, p. 2064).

Meuer and Rupietta identify four different types of studies that combine the methods: 1. studies that use the results of classical statistical methods to perform a QCA; 2. studies in which QCA results are used as a starting point for other statistical methods; 3. studies that use statistical procedures as a robustness test in the QCA; 4. parallel application of QCA and statistical analyses (cf. Meuer and Rupietta, 2017, p. 2069). In the final evaluation, they conclude that the integration of both approaches has led to a deeper understanding of the respective phenomena under investigation (cf. ibid., p. 2079).

However, it should not be overlooked that QCA and, for example, regressions will rarely yield the same results (cf. Vis, 2012, p. 175). Both methods focus on testing different hypotheses (cf. Katz et al., 2016, p. 541). While the QCA examines the necessary and sufficient influence of configurations on an outcome, the regression aims at the average effect of an individual variable or interaction

(cf. Vis, 2012, p. 180). However, the implementability of interacting variables is much more limited than in the QCA, which can "easily deal with three-way and higher order terms" (Tatarczyk, 2018, p. 49).
There are also voices that claim, that QCA and regression rely on the same logical structure, since they both want to generalize cross-sectional findings (cf. Tatarczyk, 2018, pp. 47f.). So with the use of regression the same information about necessary und sufficient conditions could be received than with QCA (cf. Paine, 2015, p. 4). Paine concludes, that the underlying procedures would be less distinct from each other than yet claimed or thought, at least when refering to csQCA (cf. Paine, 2015, p. 27). Both procedures also need to separate causality from association (cf. Tatarczyk, 2018, p. 48, Paine, 2015, p. 4).
The undeniable difference between both is nevertheless the treatment of heteroskedasticity: While standard regression analyses can not deal with this phenomenon, QCA does not treat this as a problem. And since heteroskedasticity "might simply be a fact of the world around us" (Tatarczyk, 2018, p. 48), QCA can have an advantage in these situations.

One of the great advantages for the application of QCA in nursing science is the independence of data levels. While many classical statistical methods place high demands on the data to be analyzed, in QCA any form, from nominal to ratio, can be used and combined. Regressions, for example, in most cases require a metric scale level[2]. However, many variables in the field of nursing, which may be of analytical interest, do not meet this requirement. The organizational factors studied here, such as different care units, or the types of meal preparation, funding agencies or region, have an ordinal level and are difficult to capture using conventional statistics. However, they offer scientifically interesting starting points to investigate influences on the quality of care.
Here the QCA offers new possibilities, even if its use to uncover causal relationships is repeatedly criticized, or is bound to certain prerequirement (Baumgartner, 2014; Hug, 2013). The fact that the violation of basic assumptions leads to a limited validity of the results is, however, not a special feature of this method, but also applies to all other statistical procedures. Regressions in which the normal distribution and homoscedasticity of the residuals is not given can be doubted, as can Qualitative Comparative Analyses whose solutions are based on untenable assumptions.

Further possibilities for the use in nursing studies arise from the usability of small to medium case numbers. Many standardized procedures require a significantly higher number of cases than it is possible to collect or empirically available in many instances (cf. Fainshmidt et al., 2020, p. 10). In the political sciences, from which the QCA originates, this problem is omnipresent: the number of countries on a continent, the states of a country, the communities of a municipality or other units of investigation are empirically clearly limited and often only exist in small, double-digit numbers. Depending on the effects studied or other influencing variables, this number is too small for classical inferential statistics. In many analysis units, nursing also has only a rather small number of cases. If one leaves the resident level, the number quickly decreases. In Baden-Württemberg, for example, there are currently about 1780 nursing homes in operation[3]. Despite extensive advertising, personal contact and support, only 58 of these facilities were won to participate in PiBaWü. Many other

[2] `https://www.methodenberatung.uzh.ch/de/datenanalyse_spss.html`
[3] `https://www.statistik-bw.de/SozSicherung/Pflege/Pflege_09.jsp`

studies over the years have been working with similar case numbers in the middle two-digit range (Bravo et al., 1999; Ooi et al., 1999; Spector and Takada, 1991; Lahmann et al., 2014; Lucas et al., 2007; Xu et al., 2013; Zimmermann et al., 2019). This fundamentally limits the use of many procedures. Some studies therefore make up for this by transferring variables from the smaller number of organizations to the resident level with higher number of cases and thus obtaining seemingly larger samples. For example: Investing the influence of the type of meal preparation (central or decentral) of 15 facilities with each 65 bed on the amount of residents with unwanted weight loss should be treated as 15 cases not as $15 * 65 = 975$ ones, since only 15 different instances of possible variation are given, one for every nursing home[4]. The analysis of organizational variables at the resident level is therefore a mistake, since it artificially "inflates" the smaller effects of the first level. At the same time, purely qualitative methods also reach a limit with these numbers of cases. Case studies or cross-case analyses can only be reasonably carried out over a very limited number of cases. An in-depth comparison of 20-50 cases is not feasible. QCA therefore offers a possibility to act "half-standardizing" in these ranges of case numbers.

As already concluded in chapter 1.4, phenomena in nursing are complex and their causal reasons are difficult to access, interdependent and non-linear. Especially the ongoing discussion about the quality of care and its operationalization (cf. Wingenfeld et al., 2011) shows how difficult it can be to adequately capture resident outcomes. Many simple test procedures for correlations (e.g. Pearson, Spearman,...) can only capture linear correlations. The assumption of the additivity of effects "does not always (or perhaps even usually) reflect the manner in which we and our theories envision the process of causation" (Braumoeller, 2003, p. 212). Therefore, even in such complex circumstances, methods should be applied that take these circumstances into account.
While for a long time there was still a theory-method gap, in which adequate methods for configurational thinking were missing, this phase should now be overcome with QCA. However, there are still publications relevant to nursing which explicitly want to investigate complex adaptive systems and their effects with linear-additive methods (e.g. Anderson et al., 2003). Although the QCA is not free of problems (e.g. Thiem and Baumgartner, 2015; Thiem et al., 2020; Seawright, 2014, cf.), the methodological advantages in sight of the object under investigation must not be simply ignored.
For nursing science, this offers the possibility of using a method that explicitly takes into account a large part of the nature of its phenomena. The three components of causal complexity, especially equifinality, are appropriate ways to describe them. From a theoretical perspective it is highly unlikely, that singular causes are causal or explanatory for an outcome. Therefore the search for single, most impacting or additively cumulated variables would contradict the theoretical knowledge when investigating in this study field. This results of the example in this thesis show, that on the one hand falls do not have a single explanation when using organizational factors. On the other hand it is evident, that person-related variables also play a role in resident falls. These factors are already well researched (Balzer et al., 2013) and must be incorporated in a model that wants to comprehensively capture the reasons for fall incidents.

Strong reasons for an increased use of QCA in the nursing science, but also beyond, is the possibil-

[4] Given different assumptions, like that meal preparation is the same over all care units etc.

ity of incorporating prior knowledge. Qualitative research in nursing has been booming for several years now: By anchoring it at chairs and in curricula in German-language nursing science studies, special workshops and summer schools, as well as a large number of journals and textbooks, a wide dissemination of the corresponding methods has taken place (cf. Mayer, 2016, p. 8). As useful as these particulate results are for the development of the nursing profession and the possibilities of participatory research at a grassroots level, Mayer acknowledges that explanations and causal relationships cannot be derived from them in a way that is comparable to quantitative studies; neither do they claim to be able to do this. However, a natural scientific, economizing and numbers-driven world view demands **also** a different form of knowledge (cf. ibid., p. 10). According to the author, decisions concerning, for example, the distribution of resources in the health care system must have a knowledge base that is based on more than individual knowledge. These narrow-scoped studies can, however, provide important hints and indicators for also generally valid causes. By incorporating these in-depth findings as conditions in a QCA, they can make a decisive contribution as a theoretical foundation. Due to their methodological anchoring, they cannot be generalized in principle, but are nevertheless valid. In this way, the existing, rich fund of particulate, qualitative results can be profitably reused and abstracted by the QCA.
This recourse to existing knowledge is shared by the QCA with more quantitative approaches such as the Bayesian statistics (cf. Vis, 2012, p. 191). Here, too, fruitful interrelations can arise. Like the QCA, Bayesian methods are also less demanding with regard to the necessary number of cases and use a priori knowledge to model a distribution which is then specified by the collected data (cf. Kruschke, 2015, p. 49). In nursing science studies with a limited number of cases, both methods can be used side by side to shed light on more qualitative and quantitative aspects of a problem. In comparison to the QCA, Bayesian statistics leads a much larger niche existence, though.

QCA can also make an important contribution to nursing in the area of theory development. As in section 3.3.1 already shortly addressed, nursing in Germany lacks in large parts a profound theory development. This has been criticized since the beginning of the 2000s at the latest and continues to be so over the coming decades (cf. Stemmer, 2003; Schrems, 2011; Moers et al., 2011). The focus on qualitative research described above, which is strongly rooted in individual cases and aims at specific constellations, contributes to making abstraction and generalization more difficult. What remains is a heap of knowledge which in many cases lacks a systematic approach. As a result, carers have a lot of specialist knowledge available in care situations, but are speechless when it comes to the “big questions” of care: What is quality and how can we measure it? What quality can we offer with current resources and what means would be necessary to increase it? How can we classify the need for care in such a way that it corresponds to the workload in practice? The underlying complex phenomena **quality** and **need for care** have not yet been satisfactorily defined by nursing research. Nursing staff can only express displeasure about existing problems on the basis of subjective or even collective feelings, and can argue descriptively, but not causally. The fact that there is too little time and personnel available to adequately care for all residents is a reality that is evident to the staff of an institution. For outsiders, without direct access to the situation, however, this is at best descriptive, at worst an expression of whining. Zegelin describes this state as a permanent victim role and learned helplessness, which is also due to a lack of knowledge about the interrelationships in the health care system (cf. Zegelin, 2017, p. 40). With a study such as PiBaWü, which was

able to prove that only 21% of the time variance for nursing and care can be attributed to the respective degree of care of a resident (cf. Brühl and Planer, 2019, p. 56), it is possible to give a generalized explanation of why this "timelessness" is felt. For example, residents who, according to this assessment, would have a lower need for care can mean more time and effort for the staff than those whose need for care is classified as higher. It can therefore be shown that the underlying “theory” behind the phenomenon of the need for long-term care and the instrument for the assessment based on it does not reflect reality. Findings such as these, with a more comprehensive scope for virtually all those in need of long-term care, can be used more easily and profitably to influence existing conditions. Ultimately, however, a theory must result from this and other findings. New concepts must be created that are better suited to reflect empirical findings. Besides the mentioned ability to grasp complexity, the evaluation of theoretical arguments has been a goal of the QCA since its development (cf. Ragin, 1987, pp. 118ff.). Through intersection of the solution term with the theory-derived hunches, it can be seen which part of the prior believes can be supported by the empirical findings (cf. Schneider and Wagemann, 2012, p. 298). By intersecting the negated theory with the solution, cases where the outcome was not predicted by the assumptions can be found and the theory can be expanded or respecified. And already the formulation of a configurational theory about the phenomenon under investigation promotes theory development in the bud.
For it is not only qualitative research that suffers from lack of theory; this is equally true of quantitative research. Under the “illusion of certainty”(cf. Gigerenzer et al., 2004, p. 3), researchers forget, that with classical hypothesis testing, they only evaluate the probability of the data given that the null hypothesis is true. No statement is made about the probability of the hypothesis itself (cf. Brühl, 2020, p. 12). Thus, also mechanistic statistical testing remains empty if the reason for the test is not based on theoretical considerations. But especially “when researchers have specific [...] hypotheses, or expectations concerning alternative causal patterns” (Miller, 2017, p. 8), QCA can be useful.

Qualitative research can use the QCA in a special way for the further development of the own research tradition. Tatarczyk describes QCA as “arguably the most formalized of what is usually unterstood as a qualitative method” (Tatarczyk, 2018, p. 45). By strongly interweaving quantitative elements with a qualitative basis, a possibility of abstraction is created that was not possible before. This is by no means intended to imply that the results are less “true” so far. Rather, this extension represents an additional level that can underline the validity. In a hypothetical research project, for example, nursing staff could be asked about factors for good care. The findings of these interviews then form the basis for the selection of conditions for a QCA in which larger amounts of data are collected. Their results can then form the starting point for further individual case studies of cases with special significance (unique constellations or typical cases (cf. Kahwati and Kane, 2019, pp.169f.)). Thus, an iterative circle of qualitative in-depth insights and quantitative-abstracting data can emerge, which brings questions and phenomena within a complex adaptive system ever closer together.

Even if faulty or incorrect conditions are problematic for a QCA, its use has less relevant effects than, for example, in a regression. The “omitted variable bias” there, if the model is incorrectly specified, causes estimators for the effect to become inconsistent (cf. Fainshmidt et al., 2020, p. 4).

The influence of the included variables is distorted and the significance becomes doubtful.
In a QCA, on the other hand, the absence of a central condition is not compensated for by incorrect over- or underestimation of the other conditions. In the first place, the parameters of fit decrease, but the solutions are not subject to a bias (cf. ibid.). This relaxes the selection of appropriate conditions.

Despite these advantages, QCA is of course not a “one-size-fits-all” remedy for methodological problems in nursing science, by means of which all complex phenomena can now be explained. Its application ultimately always requires a question of configurative nature. Even if, as shown in chapter 1, many questions **are** complex and interdependent due to the nature of the subject, not all of them require such a procedure. QCA has a number of specific positive aspects which make it interesting for nursing science. As always, however, the method must be adapted to the object and the interest in knowledge.

Difficulties in application for nursing sciences arise first and foremost from the strong recurrence on theories. They are an essential factor in the conception and design of many steps of the QCA. The theoretically sound selection of conditions is part of the justification of the causal relationships at the end. Theories based on content can also influence the calibration values. As described above, however, theories for the explanation and cause of nursing phenomena are missing in many places. Too often, only the description or “symptom” of a factor is given. Thus, for example, in the absence of a more comprehensive theory in regards of content, the MDK’s assessment of the need for care in many places only collects the **consequences** of the need for care. Module 4, “Self care”, and module 5, “Management and independent handling of demands and burdens caused by illness or therapy”, for example, cover very comprehensively the deficits resulting from care **causes**: Ability to care for the body independently, eating and drinking, number of necessary medication, changing bandages, doctor’s visits etc. (cf. N.N., 2017b, pp. 74-77). This results in a complicated (but not complex!) assessment procedure, which is nevertheless not suitable to capture the complexity of the subject (cf. Brühl and Planer, 2019, pp. 105ff.). With more knowledge or assumptions about the causal factors of need for care, leaner and at the same time more efficient methods of classification could be developed.
In order to be able to apply Qualitative Comparative Analysis profitably, however, nursing must find a way out of its established, theoretical speechlessness. Ragin also recognizes that this is not easy and is also a general problem of the social sciences:

“When theories are weak, they offer only general chracterizations of social phenomena and do not address causal complexity. Clear specifications of relevant contexts and scope conditions are rare, as is consideration of how causal conditions may modify each other’s relevance or impact [...]. Researchers are fortunate if they are able to derive coherent lists of potentially relevant causal conditions from most theories of social sciences, for the typical theory offers very little specific guidance.” (Ragin, 2008, p. 178).

Although the possibility remains open to justify a selection by the inductive approach of selecting conditions even without a comprehensive theory, the present study has also shown that in cases where virtually nothing is known about the interactions between and the influence of conditions on the outcome, this is little more than fishing in troubled waters.

A recommendation in such cases would therefore be to carry out preliminary studies or at least smaller pre-tests, as far as possible. From selective data collection on a small scale to comprehensive, qualitative studies, many things would be conceivable here. Always with the goal of generating a priori knowledge (or at least assumptions) that can be incorporated into the later QCA. Here again, the connection to Bayesian static becomes clear and the possibility of combining both approaches within one research project becomes apparent.

QCA also has no way of dealing with missing values in a meaningful way. If the data set contains gaps in certain cases, these must be excluded from the analysis. Missing values ultimately mean that a case cannot be assigned to any row of the truth table. To achieve this, the consistency of the assumption of belonging to each ideal type is checked. This can not be done if no information is available for one or more conditions of a case. One approach that the software TOSMANA follows is to assume all possible values for missing values one after the other and to generate solutions based on these assumptions (cf. Thiem et al., 2014, p. 18f.). However, this leads to a quickly unmanageable amount of possible solutions. In addition, the aspects of counterfactual analysis then again plays a role. For in the end, here too, values must be assumed for empirically existing cases that have not been reported due to circumstances practical research faces.
At the same time, the exclusion of cases in a method that wants to be case-oriented and thus case-sensitive inevitably leads to a loss of empirical diversity. Due to the methodology, however, a different approach is not possible.

A not so prominent and less discussed, underlying assumption is QCAs case independence. A one that is also part of other variable-oriented techniques (vgl. Marx et al., 2013, S. 123). By assuming that the cases don't influence each other a statement is made, that might not be maintainable in every context of the usage of QCA. It is possible that there is also an interrelatedness between cases, if they are in close proximity to each other. In this thesis here, often two or three cases, the care units, are located in the same geographical place, situated in the same facility. It not unthinkable that they have interacting effects on each other, even though they are, administratively, treated as two individual parts. That's why Marx, Rihoux and Ragin suggest the use of additional conditions, that take interrelatedness into account or use other methods to capture it. It is however an underregarded instance, whose implications and influence for the practical use have not yet been widely examined.

QCA is often described primarily as a method for small and medium case numbers. However, this was not an original goal in the development of the method. On the contrary, it should be able to handle a large number of cases (cf. Ragin, 1987, p. 82+121). At least since the development of software and powerful algorithms for truth table analysis such as Consistency Cubes (Duşa, 2018), the number of cases and of conditions is almost unlimited. This favored the development of large-n QCA approaches, which is also able to work with several thousand cases in the sense of a quantitative tradition. However, this "drilling up" of the method comes at the price of a turning away from the original principles, such as a subsequent in-depth analysis of certain cases. Individual case knowledge inevitably decreases with the increase in sample size and only exemplary analyses can then follow a QCA (cf. Vis, 2012, p. 191).

The increase in the number of conditions leads to an exponential increase in possible configurations. The fact that methodological problems can arise if the case-condition ratio is insufficient is shown by the study of Marx and Duşa, at least for csQCA (Marx and Duşa, 2011). It is logical to assume that this is also true for fsQCA. For the solution, however, the problem arises that configurations consisting of multiple conditions are difficult to interpret in terms of content (cf. Rutten, 2020, p. 18). The existing complexity can thus be captured, but the comprehensibility of causal relationships is reduced. This is also shown by this thesis, which has produced several solutions with 3-4 conditions. A final interpretation was only possible to a certain extent.
Ultimately, there must be a weighing up of the extent to which it is justifiable to be able to grasp complex relationships more comprehensively, but less deeply in terms of content. Or whether it is better to limit it to a few cases and conditions. However, the approach seems too potent for this to pass up this opportunity, especially with regard to nursing science.

A side topic that came to the authors notice is, that in many textbooks crucial aspects of the QCA are treated merely rudimentary, namely case and condition selection. Schneider and Wagemann, in both their publications, skip the process of selecting conditions. In their 2007 book they only mention, that much time and expertise should be spent on this process (cf. Schneider and Wagemann, 2007, p. 45). Case selection is no topic. That calibration is basically omitted in their earlier work can be explained by the fact, that an elaborate treatment of this topic for fuzzy sets was not in the focus until Ragins "Redesigning Social Inquiry" in 2008. After all, their 2012 textbook dedicates a short subsection to calibration. 2009 Berg-Schlosser and De Meur offer the first more comprehensive overview that is based on theories (see section 3.3.1) rather than on examples (Berg-Schlosser and Meur, 2009). A really hands-on explanation with the purpose of teaching the method was provided by Kahwati and Kane in 2019. Ragins most cited works (Ragin, 1987, 2000, 2008) are rather presentations of the theoretical concepts he developed for QCA, than decent ways for novices to learn the method. By missing to comprehensively translate the aspects of case and sample selection in the arising textbooks, knowledge dissemination into the practice was hindered. In most cases Ragin also only spoke about using "theoretical and substantive knowledge" to guide these processes, without further explaining what can be understood by this.

All in all QCA is a method that is still in constant motion: New papers adress smaller and greater topics or problems, like aspects of gooodness of fit. Haesebrouck for example introduced a new consistency formula in 2015 that would solve the problem that "cases with a larger membership score in the subset not always have greater bearing on the result" (Haesebrouck, 2015, p. 67f.) of the original consistency formula by Ragin. Veri proposes an other consistency formula that is able to differ randomly-generated subsets from meaningful subset relationships, what would be not the case with the old consistency measure (cf. Veri, 2019).
In the same year Duşa introduced the concept of "robust sufficiency" as a way of obtaining solutions that are parimonious while not risking to violate the principles of sufficiency (Duşa, 2019b).
Ongoing debates about causality and T/ESA between QCA "critics" like Michael Baumgartner or Alrik Thiem on the one side and "proponents" like Carsten Schneider on the other side show a strong and fruitful dialogue in an evolving method (e.g. Thiem and Baumgartner, 2015; Thiem et al., 2020; Baumgartner, 2014; Baumgartner and Thiem, 2017; Schneider, 2018).

Together with an exceptionally networked community on the internet including a Facebook group involving renowned QCA scholars like Eva Thomann or Thomas Greckhamer a very encouraging atmosphere was created where development can take place. The author is sure that this is one aspect that fundamentally helped and will help in the further progress of the advancement of QCA.

Chapter 7

Conclusion

With this work it could be shown that organizational factors which do not relate to persons, such as those which apply to factors such as “leadership” etc., also have a clear influence on the outcome of residents in nursing homes. Especially the external and structural characteristics of facilities, i.e. the number of residents or the location within a region, have an effect on internal processes and are therefore also agents of the CAS “nursing home”. Even comprehensive research on the subject of falls, such as the DNQP expert standard, does not include such factors (cf. Balzer et al., 2013, pp. 44ff.). Falls are highly complex events that can be caused by a variety of triggers (cf. Mai, 2010, p. 29). The current focus therefore needs to be broadened to create a more comprehensive understanding of why residents in nursing homes fall.
However, a rethink should not only be made in the case of falls, but the context should also be considered for all further investigations in the nursing environment. And this should not be limited to examining what **persons** bring into the system, but also what effects external structures have. Unfortunately, this happens far too rarely. Only few current studies could be identified which examine organizational influences.

PiBaWü has also uncovered a decisive factor for diverging organizational factors: Since the classification system for the Pflegegrade has considerable flaws in its construction (cf. Brühl and Planer, 2016), residents with the same combinations of characteristics receive different degrees. In some of the participating facilities, residents with the most significant combination of characteristics identified for nursing and care time were distributed across all five degrees of care (cf. Brühl and Planer, 2019, pp. 67f.). Since staffing is linked to the resident structure of a facility (more residents with higher PGs means more staff), random variance in staffing occurs. As a result, different amounts of personnel are available without this being justified by the existing neediness of the residents. This in turn results in different possibilities for the staff to care for the residents and thus different quality levels of the facilities. This randomness within the German geriatric care landscape leads to blatant problems and injustices. This again shows that organizational factors can lie outside the direct influence of an institution and can have a tangible influence on everyday life in professional care.

However, in direct comparison with the United States, the general data situation on organizational factors is rather poor. While in the USA there has been an extensive collection and provision of organizational and aggregated resident characteristics for every institution for years, this is only just beginning in Germany. OSCAR (Online Survey, Certification and Reporting) of the American Health Care Association (`https://www.ahcancal.org/research_data/oscar_data/Pages/WhatisOSCARData.aspx`) bundles a wealth of data, which can also be used scientifically (e.g. cf. Xu et al., 2013; Castle et al., 2015). The “transparency reports” carried out in Germany up to the end of 2019 also contained a section on “structural data”. It included nursing priorities, range of services (number and type of rooms) and information on the number and qualifications of staff. However, this was either not collected nationwide or not published online. The corresponding information is empty for all homes that were randomly checked (`https://www.pflege-navigator.de/index.php?module=nursinghome`).

With the introduction of the new guidelines of the GKV-Spitzenverband for the quality inspection in nursing homes (N.N., 2019), surveys on information on the facility were again established. The guidelines themselves do not reveal what this information comprises. However, it can be seen from the facilities that have so far been inspected under the new system and the quality information published that the information is much more comprehensive than before. For example, aspects such as meals, external services, nursing priorities, staff and qualifications or cooperation with other players in the health care system can be found in the report. Since the procedure has only just been introduced, it will take some time until this comprehensive data for all facilities is available. However, the scientific community should not neglect to make use of this "treasure" of information when the time comes. Organizational factors offer a "new" and expanded access to the explanation of phenomena in nursing, which must be used more extensively.

In many cases, the complexity of interrelationships in care institutions is underestimated. Despite existing considerations and findings on the nature of nursing homes as Complex Adaptive Systems, researchers too often act with methods of classical statistics, which are not able to uncover corresponding relationships. Due to its methodological basis, the QCA is a potent tool for nursing science to generate new insights. For this purpose, however, the problem of the lack of theory must be addressed in order to create robust presumptions. In addition to an exit out of the own speechlessness, this opens up access to further methods such as Bayesian statistics, which offers similar advantages. It is to be expected that research designs that combine both approaches in the sense of a Mixed Methods Design will be particularly effective for the questions of nursing science. As far as the author is aware, there is no work that has been carried out in this way yet.

The insight into organizational complexity must also guide the way we think and design work in nursing homes in the future. Complex Adaptive Systems elude central control, since changes cannot be brought about in the sense of a cause-and-effect relationship. Changes affect all agents of the system and influence them. For this reason, small-scale changes can only achieve a lasting effect by chance. With complexity science as a framework it will be essential to conduct analyses on a wide range of levels to investigate, in which way systems may can be affected in desired ways.
Uncertainties must and are accepted in research on this theoretical basis (cf. Khan et al., 2018, p. 6). Illusions of keeping variables constant and the targeted, experimental variance of a single factor to test its singular influence must be finally overcome for social reality. They must be replaced by the awareness that the connection between agents of social phenomena is in constant change and therefore never exhaustive. This is in no way a capitulation to empiricism, but rather a necessary and adequate respect for the complexity that prevails there. Scientific methods must adapt to this counter-ness and not try to force the object into their corset of preconditions. This also requires that management and research rethink their own place within a system. They themselves are part of the CAS "nursing" and by no means external observers (cf. McDaniel and Driebe, 2001, p. 24). Therefore their efforts to change must also include themselves as agents: What influences by actors

are they subject to? How do they themselves influence the system and what does this mean for other levels? Complexity thinking in the health care system therefore requires that actors also act against learned, structural and social norms (see Khan et al., 2018, p. 6). Anderson et al. argue, for example, that due to the small number of professionals, it is believed that an authoritative approach to hierarchical communication would be the best way to achieve desired results. This in turn would create barriers to self-organization as an integral factor "to develop useful behavior for the demands at the moment"(Anderson et al., 2003, p. 2). This places great demands on future change management in organizations. However, it will be an unavoidable path that must be taken. Ultimately, meaningful change can only take place if the real circumstances and the complexity are taken into account. Not only in theory but also in practice and in the research methods chosen. Qualitative Comparative Analysis can be a way to grasp and process complexity in health care facilities and thus uncover ways in which these Complex Adaptive Systems can be influenced.
But even though little concrete research has been done so far to investigate the complexity in nursing homes, one thing is already clear: Nursing homes differ significantly from soliloquizing thermostats!

Chapter 8

Appendix

8.1 Overview literature research - QCA application

Table 8.1: literature research: complete list of findings (sorted by year)

#	Titel	Author/s	Year
2	What non-technical skills competencies are addressed by Australian standards documents for health professionals who work in secondary and tertiary clinical settings? A qualitative comparative analysis	Monica Peddle, Margaret Bearman, Natalie Radomski, Lisa Mckenna, Debra Nestel	2018
6	The experience of lived space in persons with dementia: a systematic meta-synthesis	Linn Hege Forsund, Ellen Karine Grov, Anne-Sofie Helvik, Lene Kristine Juvet, Kirsti Skovdahl, Siren Eriksen	2018
10	Protocol for a meta-integration: investigating positive aspects of caregiving in dementia	Camille Branger, Megan E O?Connell, Shelley Peacock	2018
17	Restructuring physical micro-environments to reduce the demand for meat: a systematic review and qualitative comparative analysis	Filippo Bianchi, Emma Garnett, Claudia Dorsel, Paul Aveyard, Susan A Jebb	2018
19	Health care access for rural youth on equal terms? A mixed methods study protocol in northern Sweden	Isabel Goicolea, Dean Carson, Miguel San Sebastian, Monica Christianson, Maria Wiklund, Anna-Karin Hurtig	2018
32	Inside help: An integrative review of champions in healthcare-related implementation	Edward J Miech, Nicholas A Rattray, Mindy E Flanagan, Laura Damschroder, Arlene A Schmid, Teresa M Damush	2018
34	Assessing social quality of sheltered independent housing: challenges of scale and group mix	T. G. M. Spierings, P. M. Ache	2018
35	Identifying and understanding the health and social care needs of older adults with multiple chronic conditions and their caregivers: a scoping review	Katherine S. McGilton, Shirin Vellani, Lily Yeung, Jawad Chishtie, Elana Commisso et al.	2018

43	Colliding ideals ? an interview study of how intervention researchers address adherence and adaptations in replication studies	Ulrica von Thiele Schwarz, Ulrika Förberg, Knut Sundell, Henna Hasson	2018
45	Addressing Health Equity Through Action on the Social Determinants of Health: A Global Review of Policy Outcome Evaluation Methods	Janice Lee, Ashley Schram, Emily Riley, Patrick Harris, Fran Baum, Matt Fisher, Toby Freeman, Sharon Friel	2018
46	Hospitals Negotiating Leverage with Health Plans: How and Why Has It Changed?	Kelly J Devers, Lawrence P Casalino, Liza S Rudell, Jeffrey J Stoddard, Linda R Brewster, Timothy K Lake	2018
48	The Impact of a Clinical Asthma Pathway on Resident Education	Hina J. Talib, Yonit Lax, Marina Reznik	2018
53	Involving the public in epidemiological public health research: a qualitative study of public and stakeholder involvement in evaluation of a population-wide natural policy experiment	Rachel Anderson de Cuevas, Lotta Nylen, Bo Burström, Margaret Whitehead	2018
58	Assessing for domestic violence in sexual health environments: a qualitative study	Jeremy Horwood, Andrew Morden, Jayne E Bailey, Neha Pathak, Gene Feder	2018
69	Racial/Gender Biases in Student Clinical Decision-Making: a Mixed-Method Study of Medical School Attributes Associated with Lower Incidence of Biases	Williams RL, Vasquez CE, Getrich CM, Kano M, Boursaw B, Krabbenhoft C, Sussman AL.	2018
70	The role of empathy and emotional intelligence in nurses' communication attitudes using regression models and fuzzy-set qualitative comparative analysis models	Gimenez-Espert MDC, Prado-Gasco VJ	2018
90	A fuzzy set qualitative comparative analysis of 131 countries: which configuration of the structural conditions can explain health better?	Toktam PaykaniHassan RafieyHomeira Sajjadi	2018
91	Interventions targeting conscious determinants of human behaviour to reduce the demand for meat: a systematic review with qualitative comparative analysis	Filippo BianchiClaudia DorselEmma GarnettPaul AveyardSusan A Jebb	2018
97	Proceedings of the 4th Biennial Conference of the Society for Implementation Research Collaboration (SIRC) 2017: implementation mechanisms: what makes implementation work and why? part 2		2018
101	Private Sector Providers and Patterns of Privatization	Jonas Pieper	2018
110	Private Sector Providers in Political Processes	Jonas Pieper	2018
114	Meta-Synthesis of Qualitative Research	Angela J. Dawson	2018
134	Advancing Implementation: Toward an Inclusive View of Research in Behavioral Medicine	Dean L. Fixsen, BoothroydKaren A. BlaseAmanda A. M. FixsenAllison J. Metz	2018

138	A Configurational Role of Human Capital Resources in the Quality of Work Life of Marketers: FsQCA and SEM Findings from Vietnam	Nguyen Dinh Tho	2018
145	Introduction	Jonas Pieper	2018
149	Cost-effective service excellence	Jochen WirtzValarie Zeithaml	2018
154	Reciprocal Influences Involving Workplace Bullying: The Case of Role Stressors	Karen HarlosCamilla M. Holmvall	2018
158	Embracing uncertainty, managing complexity: applying complexity thinking principles to transformation efforts in healthcare systems	Sobia KhanAshley VandermorrisJohn ShepherdJames W. BegunHolly Jordan LanhamMary Uhl-BienWhitney Berta	2018
174	Configurations of factors affecting triage decision-making: A fuzzy-set qualitative comparative analysis	Ponsiglione, Cristina; Ippolito, Adelaide;Primario, Simonetta; Zollo, Giuseppe	2018
1	The effect of family policies and public health initiatives on breastfeeding initiation among 18 high-income countries: a qualitative comparative analysis research design	Amanda Marie Lubold	2017
9	Elderly and technology tools: a fuzzyset qualitative comparative analysis	Rana Mostaghel, Pejvak Oghazi	2017
12	The implementation of health promotion in primary and community care: a qualitative analysis of the ?Prescribe Vida Saludable? strategy	Catalina Martinez, Gonzalo Bacigalupe, Josep M. Cortada, Gonzalo Grandes, Alvaro Sanchez, Haizea Pombo, Paola Bully, on behalf of the PVS group	2017
15	Abstracts from the 2017 Society of General Internal Medicine Annual Meeting		2017
24	Quality improvement, implementation, and dissemination strategies to improve mental health care for children and adolescents: a systematic review	Valerie L. Forman-Hoffman, Jennifer Cook Middleton, Joni L. McKeeman, Leyla F. Stambaugh, Robert B. Christian, Bradley N. Gaynes, Heather Lynne Kane, Leila C. Kahwati, Kathleen N. Lohr, Meera Viswanathan	2017
26	Proceedings of the 4th Biennial Conference of the Society for Implementation Research Collaboration (SIRC) 2017: implementation mechanisms: what makes implementation work and why? part 2: Seattle, WA, USA. September 7-9, 2017		2017
29	Just Say No to the TPP: A Democratic Setback for American and Asian Public Health: Comment on "The Trans-Pacific Partnership: Is It Everything We Feared for Health?"	Carles Muntaner, Deb Finn Mahabir	2017

31	Improving prescribing practices with rapid diagnostic tests (RDTs): synthesis of 10 studies to explore reasons for variation in malaria RDT uptake and adherence	Helen E D Burchett, Baptiste Leurent, Frank Baiden, Kimberly Baltzell, Anders Björkman et al.	2017
36	Priorities and strategies for improving Roma women's access to primary health care services in cases on intimate partner violence: a concept mapping study	Carmen Vives-Cases, Isabel Goicolea, Alison Hernandez, Belen Sanz-Barbero, MCarmen Davo-Blanes, Daniel La Parra-Casado	2017
44	Understanding the Models of Community Hospital rehabilitation Activity (MoCHA): a mixed-methods study	John Gladman, John Buckell, John Young, Andrew Smith, Clare Hulme	2017
59	Healthcare system responses to intimate partner violence in low and middle-income countries: evidence is growing and the challenges become clearer	Angela Taft, Manuela Colombini	2017
60	Patient-experienced burden of treatment in patients with multimorbidity ? A systematic review of qualitative data	Michael Rosbach, John Sahl Andersen	2017
72	The Effect of Sleep Disorders, Sedating Medications, and Depression on Cognitive Processing Therapy Outcomes: A Fuzzy Set Qualitative Comparative Analysis	Haynes PL, Emert SE, Epstein D, Perkins S, Parthasarathy S, Wilcox J.	2017
111	Proceedings from the 9th annual conference on the science of dissemination and implementation	David ChambersLisa SimpsonGila NetaUlrica von Thiele SchwarzAntoinette Percy-LaurryGregory A. AaronsGila NetaRoss BrownsonAmanda VogelShannon Wiltsey StirmanKenneth SherrRachel SturkeWynne E. NortonAllyson VarleyDavid ChambersCynthia Vinson	2017
116	Pathways to Green(er) Pastures: Reward Bundles, Human Capital, and Turnover Decisions in a Semi-Profession	Jennifer L. Nelson	2017
117	Qualitative Evidence Synthesis	Andrew Booth	2017
126	Setting the Theoretical Framework and Methodology	Huiqi Yan	2017
130	The implementation of health promotion in primary and community care: a qualitative analysis of the" Prescribe Vida Saludable" strategy	Catalina MartinezGonzalo Bacigalupe-Josep M. CortadaGonzalo GrandesAlvaro SanchezHaizea PomboPaola Bully	2017
131	Introduction	Huiqi Yan	2017
148	The Shared Health Appointments and Reciprocal Enhanced Support (SHARES) study: study protocol for a randomized trial	Michele HeislerJennifer BurgessJeffrey CassJohn F. ChardosAlexander B. GuirguisSean M. JefferyLorrie A. StroheckerAdam S. TremblayWen-Chih WuDonna M. Zulman	2017

151	Improving Medication Adherence and Health Outcomes in Older Adults: An Evidence-Based Review of Randomized Controlled Trials	Zachary A. MarcumJoseph T. HanlonMichael D. Murray	2017
152	Predicting What Will Happen When You Intervene	Nancy CartwrightJeremy Hardie	2017
159	Self-organization and social science	David AnzolaPeter Barbrook-JohnsonJuan I. Cano	2017
4	Searching for best practices of youth friendly services - a study protocol using qualitative comparative analysis in Sweden	Isabel Goicolea, Monica Christianson, Anna-Karin Hurtig, Bruno Marchal, Miguel San Sebastian, Maria Wiklund	2016
25	Proceedings from the 9th annual conference on the science of dissemination and implementation: Washington, DC, USA. 14-15 December 2016	David Chambers, Lisa Simpson, Gila Neta, Ulrica von Thiele Schwarz, Antoinette Percy-Laurry et al.	2016
28	Patient participation in postoperative care activities in patients undergoing total knee replacement surgery: Multimedia Intervention for Managing patient Experience (MIME). Study protocol for a cluster randomised crossover trial	Jo McDonall, Richard de Steiger, John Reynolds, Bernice Redley, Patricia Livingston, Mari Botti	2016
37	Challenges and strategies for sustaining youth-friendly health services: a qualitative study from the perspective of professionals at youth clinics in northern Sweden	Suzanne Thomee, Desire Malm, Monica Christianson, Anna-Karin Hurtig, Maria Wiklund, Anna-Karin Waenerlund, Isabel Goicolea	2016
47	Development of a model for integrated care at the end of life in advanced dementia: A whole systems UK-wide approach	Louise Jones, Bridget Candy, Sarah Davis, Margaret Elliott, Anna Gola et al.	2016
61	Enhanced Recovery After Surgery Program in Patients Undergoing Pancreaticoduodenectomy: A PRISMA-Compliant Systematic Review and Meta-Analysis	Junjie Xiong, Peter Szatmary, Wei Huang, Daniel de la Iglesia-Garcia, Quentin M. Nunes, Qing Xia, Weiming Hu, Robert Sutton, Xubao Liu, Michael G. Raraty	2016
73	Strategies To Improve Mental Health Care for Children and Adolescents	Forman-Hoffman VL, Middleton JC, McKeeman JL, Stambaugh LF, Christian RB, Gaynes BN, Kane HL, Kahwati LC, Lohr KN, Viswanathan M	2016
75	The effect of nutrition education on nutrition-related health outcomes of Aboriginal and Torres Strait Islander people: a systematic review	Schembri L, Curran J, Collins L, Pelinovskaia M, Bell H, Richardson C, Palermo C	2016
88	Identifying configurations of behavior change techniques in effective medication adherence interventions: a qualitative comparative analysis	Leila KahwatiMeera ViswanathanCarol E. GolinHeather KaneMegan LewisSara Jacobs	2016

96	Proceedings of the 8th Annual Conference on the Science of Dissemination and Implementation	David ChambersLisa SimpsonFelicia Hill-BriggsGila NetaCynthia VinsonDavid ChambersRinad BeidasSteven MarcusGregory AaronsKimberly HoagwoodSonja SchoenwaldArthur EvansMatthew HurfordRonnie RubinTrevor HadleyFrances Barg	2016
104	Combined Effects: The Influence of Organizational Form and Structural Characteristics on Contract Performance in Mixed Sector Markets	Julia L. Carboni	2016
136	Globalization and Subnational Governments	Robert Agranoff	2016
141	Identifying context and cause in small-N settings: a comparative multilevel analysis	Eva ThomannAnita Manatschal	2016
3	Proceedings of the 3rd Biennial Conference of the Society for Implementation Research Collaboration (SIRC) 2015: advancing efficient methodologies through community partnerships and team science: Seattle, WA, USA. 24-26 September 2015		2015
5	Abstracts from the 38th Annual Meeting of the Society of General Internal Medicine		2015
68	What non-technical skills competencies are addressed by Australian standards documents for health professionals who work in secondary and tertiary clinical settings? A qualitative comparative analysis	Peddle M, Bearman M, Radomski N, Mckenna L, Nestel D.	2018
11	Mechanisms that Trigger a Good Health-Care Response to Intimate Partner Violence in Spain. Combining Realist Evaluation and Qualitative Comparative Analysis Approaches.	Goicolea I, Vives-Cases C, Hurtig AK, Marchal B, Briones-Vozmediano E, Otero-Garcia L, Garcia-Quinto M, San Sebastian M.	2015
13	Proceedings of the 8th Annual Conference on the Science of Dissemination and Implementation: Washington, DC, USA. 14-15 December 2015	David Chambers, Lisa Simpson, Felicia Hill-Briggs, Gila Neta, Cynthia Vinson et al.	2015
71	Health care access for rural youth on equal terms? A mixed methods study protocol in northern Sweden	Goicolea I, Carson D, San Sebastian M, Christianson M, Wiklund M, Hurtig AK.	2018
23	ABM Clinical Protocol #19: Breastfeeding Promotion in the Prenatal Setting, Revision 2015	Casey Rosen-Carole, Scott Hartman	2015
85	But not both: the exclusive disjunction in qualitative comparative analysis (QCA)	Ursula Hackett	2015
74	Searching for best practices of youth friendly services - a study protocol using qualitative comparative analysis in Sweden	Goicolea I, Christianson M, Hurtig AK, Marchal B, San Sebastian M, Wiklund M.	2016
105	Abstracts		2015

120	Health Psychology	Joanna Semlyen	2015
137	Analysing implementer narratives on addressing health inequity through convergent action on the social determinants of health in India	Devaki NambiarArundati MuralidharanSamir GargNayreen DaruwallaPrathibha Ganesan	2015
139	A stitch in time saves nine? A repeated cross-sectional case study on the implementation of the intersectoral community approach Youth At a Healthy Weight	Rianne MJJ van der KleijMathilde R CroneTheo GWM PaulussenVivan M van de GaarRia Reis	2015
150	What Types of Young People Are Bound for Higher Education at the Age of 17?	Judith Glaesser	2015
156	Intervention Component Analysis (ICA): a pragmatic approach for identifying the critical features of complex interventions	Katy SutcliffeJames ThomasGillian StokesKate HindsMukdarut Bangpan	2015
163	Secondary Schooling Careers in England	Judith Glaesser	2015
16	System Dynamics Modeling in the Evaluation of Delays of Care in ST-Segment Elevation Myocardial Infarction Patients within a Tiered Health System	Luciano de Andrade, Catherine Lynch, Elias Carvalho, Clarissa Garcia Rodrigues, Joao Ricardo Nickenig Vissoci, Guttenberg Ferreira Passos, Ricardo Pietrobon, Oscar Kenji Nihei, Maria Dalva de Barros Carvalho	2014
20	Physician organization care management capabilities associated with effective inpatient utilization management: a fuzzy set qualitative comparative analysis	Thomas J Sheehy, N Marcus Thygeson	2014
84	Physician organization care management capabilities associated with effective inpatient utilization management: a fuzzy set qualitative comparative analysis	Thomas J SheehyN Marcus Thygeson	2014
22	Abstracts from the 37th Annual Meeting of the Society of General Internal Medicine		2014
86	Elderly and technology tools: a fuzzyset qualitative comparative analysis	Rana MostaghelPejvak Oghazi	2017
87	Searching for best practices of youth friendly services - a study protocol using qualitative comparative analysis in Sweden	Isabel GoicoleaMonica ChristiansonAnna-Karin HurtigBruno MarchalMiguel San SebastianMaria Wiklund	2016
27	Behavior Change Pathways to Voluntary Medical Male Circumcision: Narrative Interviews with Circumcision Clients in Zambia	Jessica E. Price, Lyson Phiri, Drosin Mulenga, Paul C. Hewett, Stephanie M. Topp, Nicholas Shiliya, Karin Hatzold	2014
39	Measuring Success in Health Care Value-Based Purchasing Programs: Findings from an Environmental Scan, Literature Review, and Expert Panel Discussions	Cheryl L. Damberg, Melony E. Sorbero, Susan L. Lovejoy, Grant R. Martsolf, Laura Raaen, Daniel Mandel	2014

41	Improving the experience of dementia and enhancing active life - living well with dementia: study protocol for the IDEAL study	Linda Clare, Sharon M Nelis, Catherine Quinn, Anthony Martyr, Catherine Henderson	2014
42	Defining and Identifying Members of a Research Study Population: CTSA-Affiliated Faculty Members	Jonathan D. Eldredge, Edward F. Weagel, Philip J. Kroth	2014
92	Quality of life of residents with dementia in long-term care settings in the Netherlands and Belgium: design of a longitudinal comparative study in traditional nursing homes and small-scale living facilities	Alida HPM de RooijKatrien G LuijkxAnja G DeclercqJos MGA Schols	2011
93	Abstracts from the 2017 Society of General Internal Medicine Annual Meeting		2017
94	Abstracts from the 38th Annual Meeting of the Society of General Internal Medicine		2015
95	Abstracts from the 37th Annual Meeting of the Society of General Internal Medicine		2014
49	Narrative reviews	Jong-Myon Bae	2014
52	Study protocol for a randomized, controlled, superiority trial comparing the clinical and cost- effectiveness of integrated online mental health assessment-referral-care in pregnancy to usual prenatal care on prenatal and postnatal mental health and infant health and development: the Integrated Maternal Psychosocial Assessment to Care Trial (IMPACT)	Dawn Kingston, Marie-Paule Austin, Kathy Hegadoren, Sheila McDonald, Gerri Lasiuk	2014
55	Understanding differences in electronic health record (EHR) use: linking individual physicians? perceptions of uncertainty and EHR use patterns in ambulatory care	Holly Jordan Lanham, Dean F Sittig, Luci K Leykum, Michael L Parchman, Jacqueline A Pugh, Reuben R McDaniel	2014
99	Proceedings of the 3rd Biennial Conference of the Society for Implementation Research Collaboration (SIRC) 2015: advancing efficient methodologies through community partnerships and team science	Cara LewisDoyanne DarnellSuzanne Kerns-Maria Monroe-DeVitaSara J. LandesAaron R. LyonCameo StanickShannon DorseyJill LockeBrigid MarriottAjeng PuspitasariCaitlin DorseyKarin HendricksAndria PiersonPhil FizurKatherine A. Comtois	2016
63	Mimiviridae, Marseilleviridae, and virophages as emerging human pathogens causing healthcare-associated infections	Anton G. Kutikhin, Arseniy E. Yuzhalin, Elena B. Brusina	2014
76	Healthcare organization-education partnerships and career ladder programs for health care workers	Dill JS, Chuang E, Morgan JC.	2014
77	System dynamics modeling in the evaluation of delays of care in ST-segment elevation myocardial infarction patients within a tiered health system	de Andrade L, Lynch C, Carvalho E, Rodrigues CG, Vissoci JR, Passos GF, Pietrobon R, Nihei OK, de Barros Carvalho MD.	2014

78	The 'active ingredients' for successful community engagement with disadvantaged expectant and new mothers: a qualitative comparative analysis	Brunton G, O'Mara-Eves A, Thomas J.	2014
89	Using qualitative comparative analysis (QCA) in systematic reviews of complex interventions: a worked example	James Thomas, Alison O?Mara-Eves, Ginny Brunton	2014
102	Managing Service Delivery Networks Strategically	Daniela Cristofoli, Laura Maccio, Josip Markovi, Marco Meneguzzo	2014
106	The experience of lived space in persons with dementia: a systematic meta-synthesis	Linn Hege F?rsundEllen Karine GrovAnne-Sofie HelvikLene Kristine JuvetKirsti SkovdahlSiren Eriksen	2018
107	Health care access for rural youth on equal terms? A mixed methods study protocol in northern Sweden	Isabel GoicoleaDean CarsonMiguel San SebastianMonica ChristiansonMaria WiklundAnna-Karin Hurtig	2018
108	Racial/Gender Biases in Student Clinical Decision-Making: a Mixed-Method Study of Medical School Attributes Associated with Lower Incidence of Biases	Robert L. Williams MD, MPHCirila Estela Vasquez PhDChristina M. Getrich PhD-Miria Kano PhDBlake Boursaw MSCrystal Krabbenhoft BSAndrew L. Sussman PhD, MCRP	2018
143	The use of systematic reviews to analyse demand-side management policy	Peter Warren	2014
18	Using qualitative evidence on patients? views to help understand variation in effectiveness of complex interventions: a qualitative comparative analysis	Bridget Candy, Michael King, Louise Jones, Sandy Oliver	2013
21	Using case study within a sequential explanatory design to evaluate the impact of specialist and advanced practice roles on clinical outcomes: the SCAPE study	Joan G Lalor, Dympna Casey, Naomi Elliott, Imelda Coyne, Catherine Comiskey, Agnes Higgins, Kathy Murphy, Declan Devane, Cecily Begley	2013
56	Development of integrated care pathways: toward a care management system to meet the needs of frail and disabled community-dwelling older people	Nicole Dubuc, Lucie Bonin, Andre Tourigny, Luc Mathieu, Yves Couturier, Michel Tousignant, Cinthia Corbin, Nathalie Delli-Colli, Michel Raiche	2013
79	An example of qualitative comparative analysis in nursing research	Donnelly F, Wiechula R.	2013
100	Seminars		2013
115	Understanding and benchmarking health service achievement of policy goals for chronic disease	Erica BellBastian Seidel	2012
121	Do governance choices matter in health care networks?: an exploratory configuration study of health care networks	Annick WillemPaul Gemmel	2013

122	Serious Violent Offenses and Sentencing Decisions in China. Are There Any Gender Disparities?	Hong LuBin LiangSiyu Liu	2013
123	Presented Abstracts from the Thirty Second Annual Education Conference of the National Society of Genetic Counselors (Anaheim, CA, October 2013)	Anne C. MadeoEmily EdelmanKatie Darin	2013
119	Quality improvement, implementation, and dissemination strategies to improve mental health care for children and adolescents: a systematic review	Valerie L. Forman-HoffmanJennifer Cook MiddletonJoni L. McKeemanLeyla F. Stambaugh-Robert B. ChristianBradley N. GaynesHeather Lynne KaneLeila C. KahwatiKathleen N. LohrMeera Viswanathan	2017
144	Mixed Methods and Causal Analysis	David J. HardingKristin S. Seefeldt	2013
147	Evaluation of a large-scale weight management program using the consolidated framework for implementation research (CFIR)	Laura J DamschroderJulie C Lowery	2013
153	The effectiveness and cost-effectiveness of shared care: protocol for a realist review	Rebecca HardwickMark PearsonRichard ByngRob Anderson	2013
176	State Regulation of Religion and Radicalism in the Post-Communist Muslim Republics	Achilov, Dilshod; Shaykhutdinov, Renat	2013
8	A Configurational Approach to the Relationship between High-Performance Work Practices and Frontline Health Care Worker Outcomes	Emmeline Chuang, Janette Dill, Jennifer Craft Morgan, Thomas R Konrad	2012
33	Understanding and benchmarking health service achievement of policy goals for chronic disease	Erica Bell, Bastian Seidel	2012
40	Mapping the Mixed Methods?Mixed Research Synthesis Terrain	Margarete Sandelowski, Corrine I. Voils, Jennifer Leeman, Jamie L. Crandell	2012
127	Assessing social quality of sheltered independent housing: challenges of scale and group mix	T. G. M. SpieringsP. M. Ache	2018
54	Illumination with a Dim Bulb? What do social scientists learn by employing qualitative data analysis software (QDAS) in the service of multi-method designs?	Michael J. White, Maya D. Judd, Simone Poliandri	2012
65	Use of Qualitative Methods in Published Health Services and Management Research: A 10-Year Review	Bryan J. Weiner, Halle R. Amick, Jennifer L. Lund, Shoou-Yih Daniel Lee, Timothy J. Hoff	2012
98	Abstracts		2012
129	Affording Discretion in How Policy Objectives are Achieved: Lessons from Clinician Involvement in Managerial Decision-Making	Aoife McDermotMary A. KeatingMalcolm J. Beynon	2012

146	Impact of different exercise training modalities on the coronary collateral circulation and plaque composition in patients with significant coronary artery disease (EXCITE trial): study protocol for a randomized controlled trial	Madlen UhlemannVolker AdamsKarsten LenkAxel LinkeSandra ErbsJennifer AdamHolger ThieleThomas HilbergMatthias GutberletMartin GrunzeGerhard C SchulerSven Möbius-Winkler	2012
7	Quality of life of residents with dementia in long-term care settings in the Netherlands and Belgium: design of a longitudinal comparative study in traditional nursing homes and small-scale living facilities	Alida HPM de Rooij, Katrien G Luijkx, Anja G Declercq, Jos MGA Schols	2011
57	Using qualitative synthesis to explore heterogeneity of complex interventions	Bridget Candy, Michael King, Louise Jones, Sandy Oliver	2011
135	Identifying and understanding the health and social care needs of older adults with multiple chronic conditions and their caregivers: a scoping review	Katherine S. McGiltonShirin VellaniLily YeungJawad ChishtieElana Commisso-Jenny PloegMelissa K. AndrewAna Patricia AyalaMikaela GrayDebra MorganAmanda Froehlich ChowEdna ParrottDoug StephensLori HaleMargaret KeatingsJennifer Walker	2018
82	Explaining the success of pensioners? parties: A Qualitative Comparative Analysis of 31 polities	Hanley, SH	2011
103	Abstract		2011
112	Involvement and structure: A qualitative study of organizational change and sickness absence among women in the public sector in Sweden	Maria BaltzerHugo WesterlundMona BackhansKarin Melinder	2011
160	Journal Watch		2011
140	Using qualitative synthesis to explore heterogeneity of complex interventions	Bridget CandyMichael KingLouise Jones-Sandy Oliver	2011
50	Facilitators and barriers to implementing clinical care pathways	Sara Evans-Lacko, Manuela Jarrett, Paul McCrone, Graham Thornicroft	2010
62	Decreasing medical complications for total knee arthroplasty: Effect of Critical Pathways on Outcomes	M Elaine Husni, Elena Losina, Anne H Fossel, Daniel H Solomon, Nizar N Mahomed, Jeffrey N Katz	2010
38	Effects of clinical pathways in the joint replacement: a meta-analysis	A Barbieri, K Vanhaecht, P Van Herck, W Sermeus, F Faggiano, S Marchisio, M Panella	2009

132	SUPPORT Tools for evidence-informed health Policymaking (STP) 7: Finding systematic reviews	John N LavisAndrew D OxmanJeremy GrimshawMarit JohansenJennifer A BoykoSimon LewinAtle Fretheim	2009
161	Prescription informatisee: de l'ordre a l'itineraire clinique	Mathias Tschopp, Magali Despond, Damien Grauser, Jean-Christophe Staub, Christian Lovis	2009
162	Systemes d'informations cliniques: au coeur des informatiques hospitalieres	Prof Christian Lovis	2009
30	The Cost Consequences of Improving Diabetes Care: The Community Health Center Experience	Elbert S. Huang, Sydney E.S. Brown, James X. Zhang, Anne C. Kirchhoff, Cynthia T. Schaefer, Lawrence P. Casalino, Marshall H. Chin	2008
157	Legitimacy-Based Entry Deterrence in Inter-Population Competition	Alex Bitektine	2008
179	The Spread of the Flat Tax in Eastern Europe: A Comparative Study	Evans, Anthony John; Aligica, Paul Dragos	2008
64	Qualitative Data Analysis for Health Services Research: Developing Taxonomy, Themes, and Theory	Elizabeth H Bradley, Leslie A Curry, Kelly J Devers	2007
66	A cluster randomized controlled trial of a clinical pathway for hospital treatment of heart failure: study design and population	Massimiliano Panella, Sara Marchisio, Andrea Gardini, Francesco Di Stanislao	2007
83	Qualitative Comparative Analysis und Fuzzy Sets : ein Lehrbuch für Anwender und jene, die es werden wollen	Schneider CQ; Wagemann C	2007
142	From Words to Numbers: How to Transform Qualitative Data into Meaningful Quantitative Results	Katharina J. SrnkaSabine T. Koeszegi	2007
167	A replication study of priorities and attitudes of two nursing programs' communities of interest: an appreciative inquiry.	Farrell M; Wallis NC; Evans MT	2007
155	Globalization and Subnational Governments	Robert Agranoff	2018
51	The Transition from Excess Capacity to Strained Capacity in U.S. Hospitals	Gloria J Bazzoli, Linda R Brewster, Jessica H May, Sylvia Kuo	2006
170	Why some states have more school nurses than others: a comparative analysis.	Maughan ED	2006
14	Critical Pathway Effectiveness: Assessing the Impact of Patient, Hospital Care, and Pathway Characteristics Using Qualitative Comparative Analysis	Sydney M Dy, Pushkal Garg, Dorothy Nyberg, Patricia B Dawson, Peter J Pronovost, Laura Morlock, Haya Rubin, Albert W Wu	2005
67	Can good bed management solve the overcrowding in accident and emergency departments?	N Proudlove, K Gordon, R Boaden	2003

118	The bedford-stuyvesant healthy homes initiative: A comprehensive approach to residential hazard assessment and control		2003
128	External Factors	Gerhard Kümmel	2002
133	The Regulation of Pharmacists in Belgium and the Netherlands: In the Public or Private Interest?	N. J. PhilipsenM. G. Faure	2002
168	Ethical dilemmas in a high technology unit.	Bunch EH	2001
164	The role of empathy and emotional intelligence in nurses communication attitudes using regression models and fuzzy qualitative comparative analysis models.	Gimenez Espert, Maria del Carmen, Prado Gasco, Vincente Javier	2018
165	An example of qualitative comparative analysis in nursing research	Frank Donnelly, Richard Wiechula	2013
166	The active ingredients for successful community engagement with disadvantaged expectant and new mothers: a qualitative comparative analysis.	Ginny Brunton, Alison O'Mara-Eves, James Thomas	2014
125	Proceedings; 29th European Symposium on Clinical Pharmacy: New Technologies Pharmacists and Patients 11 - 14 October 2000, Basel, Switzerland		2000
109	Abstracts of Documents in This Supplement		1997
169	Healthcare organization education partnerships and career ladder programs for health care workers.	Janette Dill, Emmeline Chuang, Jennifer Morgan	2014
180	Why Labor Wins, Why Labor Loses: A Test of Two Theories	Biggert, Robert	1997
113	Abstracts of Documents in this Supplement		1995
172	A Configurational Approach to the Relationship between High-Performance Work Practices and Frontline Health Care Worker Outcomes	Chuang, Emmeline; Dill, Janette; Morgan, Jennifer Craft;Konrad, Thomas R	2012
173	An example of qualitative comparative analysis in nursing research	Donnelly F, Wiechula R.	2013
175	Democratic consolidation in Central America: A qualitative comparative approach	Berntzen, Einar	1993
171	A Comparative Method: Reflections on Charles Ragin's Innovations in Comparative Analysis	Markoff, John	1990
80	[Balanced course–a psychiatric nurse's working day. A qualitative comparative analysis of how 'Grounded Theory' is used as a method].	Bunch EH.	1984
177	The 'active ingredients' for successful community engagement with disadvantaged expectant and new mothers: a qualitative comparative analysis	Brunton G, O'Mara-Eves A, Thomas J.	2014

178	The role of empathy and emotional intelligence in nurses' communication attitudes using regression models and fuzzy-set qualitative comparative analysis models	Gimenez-Espert MDC, Prado-Gasco VJ	2018
124	Gay fathers	Frederick Bozett	1981
81	Limiting intrusion-social control of outsiders in a healing community: an illustration of qualitative comparative analysis	Wilson HS.	1977

8.2 Organizational factors in “PiBaWü”

Complete list of organizational factors of the research project “Pflege in Baden-Württemberg”. The order, naming and numbering is corresponding to the data collection table.

Organisationsfaktoren - Gesamteinrichtung	**Organisationsfaktoren - Organisationseinheit**
5.1 Strukturdaten	**6.1 Bauliche Gegebenheiten**
5.1.1 Lage	6.1.1 Letzte Sanierung
5.1.2 Landkreis/Stadtkreis	6.1.2 Anzahl Doppelzimmer
5.1.3 Spitzenverband	6.1.3 Anzahl Einzelzimmer
-evtl. zweiter Verband	6.1.4 Gröše der Organisationseinheit
5.1.4 Verbundeinrichtung	6.1.5 Auf Organisationseinheitsebene:
5.1.5 Baujahr	-Offene Küche/Verteilerküche
5.1.6 Gesamtfläche der Einrichtung	-Speiseräume
5.1.7 Anzahl Gebäude	-Therapieräume
5.1.8 Anzahl Organisationseinheiten	-Verteilsystem Mittagsmahlzeit
5.1.9 Mahlzeitenlieferung	6.1.6 Mehrere Stockwerke
5.1.10 Vereinbarter Stellenschlüssel Pflege	**6.2. Organisationseinheit Leitung**
-Pflegestufe 0	6.2.1 Fachliche Ausrichtung
-Pflegestufe 1	6.2.2 Beruflicher Abschluss
-Pflegestufe 2	6.2.3 Freistellungsanteil Wohngruppenleitung
-Pflegestufe 3	**6.3 Spezielles Angebot Organisationseinheit**
-Pflegestufe 3+	6.3.1 Demenz
5.1.11 Personalanhaltszahlen schwer Demenzerkrankte	6.3.2 Wachkoma
5.2 Qualitätsmanagement und Angebot besonderer Wohnbereiche	6.3.3 Beatmung
5.2.1 Zertifizierung	6.3.4 Hospiz/Palliaitv
5.2.2 Bereich Demenz	6.3.5 Hausgemeinschaftskonzept
5.2.3 Bereich Wachkoma	6.3.6 Anzahl Pflegeplätze gesamt
5.2.4 Bereich Beatmung	6.3.7 davon integrierte Tagespflege
5.2.5 Bereich Hospiz/Palliativ	6.3.8 davon "eingestreute" Tagespflege
5.2.6 Hausgemeinschaftskonzept	6.3.9 davon Nachtpflege
5.2.7 Ambulantisierte Versorgung	6.3.10 davon Kurzzeitpflege
5.2.8 Anzahl Pflegeplätze gesamt	6.3.11 Hauptsächlich Dauernachtwachen
5.2.9 davon Anzahl integrierte Tagespflege	**6.4 Mitarbeiter Organisationseinheit**
5.2.10 davon Anzahl integr. Kurzzeitpflege	*6.4.1 Anzahl Mitarbeiter Pflege*
5.2.11 davon Anzahl integrierte Nachtpflege	-Frauen
5.2.12 Stundenweise Einzelbetreuung	-Männer
5.2.13 Intensive Angehörigenarbeit	-Vollzeitkräfte
5.2.14 Intensive Begleitung der Ehrenamtlichen	-Teilzeitkräfte unter 51%

5.3 Leitung

Einrichtungsleitung

5.3.1 Stellenumfang Einrichtungsleitung
-Stellenanteil EL (%):
-Stellenanteil PDL (%):
5.3.2 Hauptamtliche Berufserfahrung
5.3.3 Fachliche Ausrichtung
5.3.4 Beruflicher Abschluss
5.3.5 Weiterbildung Einrichtungsleitung

Pflegedienstleitung

5.3.6 Stellenumfang Pflegedienstleitung
-Stellenanteil PDL (%):
-Stellenanteil EL (%):

5.3.7 Qualifikation Pflegedienstleitung
5.3.8 Freist.anteil Pflegedienstleitung
-direkte Pflege (Dezimal)
-Personalunion EL und PDL (Dezimal)
5.3.9 Sonderschlüssel PDL
5.3.10 Freist.anteil Qualitätsmanagement
-Freistellung (Dezimal)
-Personalunion QMB und PAL (Dezimal)
5.3.11 Freistellungsanteil Praxisanleitung
-direkte Pflege (Dezimal)
-Personalunion EL und PAL (Dezimal)
-Personalunion PDL und PAL (Dezimal)
5.3.12 Sonderschlüssel Qualität

5.4 Mitarbeiter gesamt

5.4.1 Anzahl Mitarbeiter Pflege
und Betreuung
-Frauen
-Männer
-Vollzeitkräfte
-Teilzeitkräfte unter 51%
-Teilzeitkräfte über/gleich 51%
-Schüler
5.4.2 Personalaufstellung
Gesamteinrichtung

Pflegefachkräfte
-Altenpflegerin
-Gesundheits-/Krankenpflegerin
-Kinderkrankenpflegerin
-Teilzeitkräfte über/gleich 51%
-Schüler

6.4.2 Anzahl Mitarbeiter Betreuung
-Frauen
-Männer
-Vollzeitkräfte
-Teilzeitkräfte unter 51%
-Teilzeitkräfte über/gleich 51%
-Schüler
6.4.3 Anzahl Mitarbeiter Betreuung gesamt
6.4.4 Stichtag der Personalaufstellung
6.4.5 Durchschnittsalter ohne Azubis
6.4.6 Personalaufstellung
Organisationseinheit

Pflegefachkräfte
-Altenpflegerin
-Gesundheits-/Krankenpflegerin
-Kinderkrankenpflegerin
davon:
-Fachkraft Gerontopsychiatrie
-Fachkraft Hospiz- und Palliativcare
-Fachkraft Onkologie
-Fachkraft Rehabilitation / Langzeitpflege
-Weiterbildung: Leiter Funktionseinheit
-Weiterbildung: Intensiv und Anästhesie
-Diplom
-Bachelor
-Master

-Studenten
-Sonstige

Weitere Fachkräfte
-Fachkräfte nach LPersVO

Assistenzkräfte
-Alltagsbetreuerin
-Altenpflegehelferin

-Gesundheits-/Krankenpflegehelferin
-Heilerziehungsassistentin
-Heilerziehungshelferin
-Pflegeassistentin

Weitere Kräfte

davon:
-Fachkraft Gerontopsychiatrie
-Fachkraft Hospiz- und Palliativcare
-Fachkraft Onkologie
-Fachkraft Rehabilitation / Langzeitpflege
-Weiterbildung: Leiter Funktionseinheit
-Weiterbildung: Intensiv und Anästhesie
-Diplom
-Bachelor
-Master
-Studenten
-Sonstige
Weitere Fachkräfte
-Fachkräfte nach LPersVO
Assistenzkräfte
-Alltagsbetreuerin
-Altenpflegehelferin
-Gesundheits-/Krankenpflegehelferin
-Heilerziehungsassistentin
-Heilerziehungshelferin
-Pflegeassistentin
Weitere Kräfte
-§43 b-Kräfte (ehemals §87b)
-Angelernte Kräfte
-Assistenzkräfte Hauswirtschaft
-BUFDI/FSJ
-Auszubildende/Studenten Pflege
Ehrenamt
5.4.3 Stichtag der Personalaufstellung
5.4.4 Durchschnittsalter ohne Azubis
5.4.5 Rückblick Erhebungsquartal
-Kumulierte Stunden vakante Stellen
-Kumulierte Krankheitsstunden
-Kumulierte Stunden Urlaub
-Kumulierte Mehrarbeitsstunden
-Kumulierte Leiharbeitsstunden
5.5. Kooperationen
5.5.1 Vertragliche Facharzt Kooperation
5.5.2 Fachärzliche Kooperationen
-Hausarzt
-Augenarzt
-HNO Arzt
-Gynäkologe

-§43 b-Kräfte (ehemals §87b)
-Angelernte Kräfte
-Assistenzkräfte Hauswirtschaft
-BUFDI/FSJ
-Auszubildende/Studenten Pflege
Ehrenamt

-Zahnarzt
-Palliativmediziner
-Weitere
5.5.3 Apotheken-Verblisterung
5.5.4 Apotheken-Bestellung
5.5.5 Spezialisierte ambulante
Palliativversorgung
5.5.6 Stationäres Hospiz
5.5.7 Ambulanter Hospizdienst
5.5.8 Leiharbeitsfirma
5.5.9 Weitere Kooperationen
-Wundmanagement
-Ernährungsberater
-Hygieneinstitut
-Ambulanter Pflegedienst
-Fort-/Weiterbildung
-Pflegeschulen
-Tagespflege
-Weitere
5.6 Konzeption der Pflege
5.6.1 Pflegekonzept
5.6.2 Pflegedokumentation
5.6.3 Verwendung SIS
5.6.4 Dokumentation nach Qualifikation
5.6.5 Pflegeplanung nach Qualifikation
5.6.6 Hauptsächlich Dauernachtwache

8.3 Overview literatur research - Organizational factors

Table 8.3: Overview literature research - Organizational factors

1	Characteristics of nursing homes that affect resident outcomes	William Spector, Hitomi Adrianna Takada	1991
2	Variations in the outcomes of care provided in Pennsylvania nursing home	Jacqueline Zinn, William Aaronson, Michael Rosko	1993
3	Correlates of Care Quality in Long-Term Care Facilities: A Multilevel Analysis	Gina Bravo, Philippe De Wals, Marie-France Dubois, Michele Charpentier	1999
4	Nursing home characteristics and the development of pressure sores and disruptive behaviour	Wee Lock Ooi, John Morris, Gary Brandeis, Monir Hossain, Lewis Lipsitz	1999
5	Differences in Nursing Homes With Increasing and Decreasing Use of Physical Restraints	Nicholas G. Castle	2000
6	The Relationship Between Organizational Factors and Resident Satisfaction with Nursing Home Care and Life	Judith A. Lucas , Carrie A. Levin, Timothy J. Lowe, Brian Robertson, Ayse Akincigil, Usha Sambamoorthi, Scott Bilder, Eun Kwang Paek, Stephen Crystal	2008
7	The Influence of Nurse Staffing Levels on Quality of Care in Nursing Homes	Kathryn Hyer, Kali S. Thomas, Laurence G. Branch, Jeffrey S. Harman, Christopher E. Johnson, Robert Weech-Maldonado	2011

8	Effect of nursing home characteristics on residents? quality of life: A systematic review	Dongjuan Xu, Robert L. Kane, Tatyana A. Shamliyan	2012
9	Quality of care and long-term care administrators? education: Does it make a difference?	Nicholas G. Castle, Jessica Furnier, Jamie C. Ferguson-Rome, Douglas Olson, Jennifer Johs-Artisensi	2015
10	Verhältnis zwischen Qualität, Preis und Profitorientierung deutscher Pflegeheime	Max Geraedts, Charlene Harrington, Daniel Schumacher,Rike Kraska	2016
11	Organizational factors of fall injuries among residents within German nursing homes: secondary analyses of cross?sectional data	Jaroslava Zimmermann, Michael Swora, Holger Pfaff, Susanne Zank	2019

8.4 R Code

```
##library##
library(QCA)
##read file##
QCAModel <- read.csv2("C:/path/path/path/QCA/QCAModel.csv", row.names=1)
#HCU = home-like care units
#DCU = dementia care units
#BED = number of beds
#INH = inhabitans of community where nursing home is located
#FALL = relative amount of residents that fell at least once in the 6 months of data collection

##calibration##
#Region#
QCAModel$URB <- calibrate(QCAModel$INH, type ="fuzzy", method ="direct",
thresholds = "e= 4999, c=20000, i=99999")
#Size#
QCAModel$BIG <- calibrate(QCAModel$BED, type = "fuzzy", thresholds = "e=20, c=64, i=100")
#Outcome#
QCAModel$FALLrel <- calibrate(QCAModel$FALL, type = "fuzzy",
thresholds = "e=0.01, c=0.09, i=0.15")
QCAModel$FALLres <- calibrate(QCAModel$FALL, type = "fuzzy",
thresholds = "e=0.01, c=0.046, i=0.15")

##Necessity relations##
superSubset(QCAModel,outcome = "FALLrel", conditions = c("BIG","URB","HLU","DCU"),
relation = "necessity", incl.cut = 0.95, cov.cut = 0.75)
superSubset(QCAModel,outcome = "FALLres", conditions = c("BIG","URB","HLU","DCU"),
relation = "necessity", incl.cut = 0.95, cov.cut = 0.75)

##truth table##
TT <- truthTable(QCAModel, outcome = "FALLrel", conditions = "HLU, DCU, URB, BIG",
incl.cut = 0.85, n.cut = 3, pri.cut = 0.75, complete = TRUE,sort.by = "incl", show.cases = TRUE,
dcc = TRUE)
TT2 <- truthTable(QCAModel, outcome = "FALLres", conditions = "HLU, DCU,URB,BIG",
incl.cut = 0.85, n.cut = 3, pri.cut = 0.75, complete = TRUE,sort.by = "incl", show.cases = TRUE,
dcc = TRUE)


##Minimization##
#conservative solution#
con <- minimize(TT, details = TRUE)
con2 <- minimize(TT2, details = TRUE)

#parsimonious solution with all remainders#
par <- minimize(TT, include="?", details = TRUE)
par2 <- minimize(TT2, include="?", details = TRUE)

#intermediate solution
#directional expectancies: HLU = -, DCU = -, BIG = 1, URB = - #
inter <- minimize(TT, include = "?", dir.exp = "BIG", details = TRUE,)
inter2 <- minimize(TT2, include = "?", dir.exp = "BIG", details = TRUE)

#check for contradictory assumptions#
findRows(obj = TT, type = 2)
findRows(obj = TT2, type = 2)
```

```
##robustness range##
calib.range(raw.data = Raw,calib.data = Calibrated,test.cond = "BIG",test.thresholds = c(20, 64, 100),step = 5,max.runs = 10,outcome = "FALLrel",
conditions = c("HLU","DCU","URB","BIG"),incl.cut = 0.85,n.cut = 3,include = "?", dir.exp = "BIG")

calib.range(raw.data = Raw,calib.data = Calibrated,test.cond = "URB",test.thresholds = c(4999,20000, 99999),step = 500,max.runs = 10,outcome = "FALLrel",
conditions = c("HLU","DCU","URB","BIG"),incl.cut = 0.85,n.cut = 3,include = "?", dir.exp = "BIG")

calib.range(raw.data = Raw,calib.data = Calibrated,test.cond = "BIG",test.thresholds = c(20, 64, 100),step = 5,max.runs = 10,outcome = "FALLres",
conditions = c("HLU","DCU","URB","BIG"),incl.cut = 0.85,n.cut = 3,include = "?", dir.exp = "BIG")

calib.range(raw.data = Raw,calib.data = Calibrated,test.cond = "URB",test.thresholds = c(4999,20000, 99999),step = 500,max.runs = 10,outcome = "FALLres",
conditions = c("HLU","DCU","URB","BIG"),incl.cut = 0.85,n.cut = 3,include = "?", dir.exp = "BIG")
```

8.5 Necessity analysis

Table 8.4: Results superset analysis

	inclN	**RoN**	**covN**
Out = "FALLrel", conditions = "BIG","URB","HLU","DCU"			
BIG+URB+ ~DCU	0.951	0.161	0.713
BIG+ ~HLU+ ~DCU	0.968	0.084	0.706
~URB+ ~HLU+DCU	0.954	0.177	0.718
~BIG+ ~URB+ ~HLU+ ~DCU	0.955	0.103	0.702
~BIG+URB+ ~HLU+ ~DCU	0.954	0.111	0.703
~BIG+URB+ ~HLU+DCU	0.963	0.133	0.714
Out = "FALLres", conditions = "BIG","URB","HLU","DCU"			
BIG+ ~URB+ ~HLU	0.954	0.192	0.788
BIG+URB+ ~DCU	0.955	0.210	0.792
BIG+ ~HLU+ ~DCU	0.969	0.110	0.783
URB+ ~HLU+ ~DCU	0.953	0.156	0.780
~BIG+ ~URB+ ~HLU+ ~DCU	0.960	0.135	0.780
~BIG+ ~URB+ ~HLU+DCU	0.958	0.205	0.793
~BIG+URB+ ~HLU+DCU	0.960	0.172	0.788
BIG+ ~URB+HLU+ ~DCU	0.950	0.198	0.787

8.6 Truth tables

Table 8.5: Truth tables - Positive outcome

#	HLU	DCU	URB	BIG	OUT	n	incl	PRI	DCC
Out = "FALLrel", conditions = "BIG","URB","HLU","DCU"									
16	1	1	1	1	1	3	1.000	1.000	
8	0	1	1	1	1	10	0.915	0.905	16-01
9	1	0	0	0	1	8	0.887	0.869	10-01
3	0	0	1	0	1	4	0.887	0.808	52-02
6	0	1	0	1	0	5	0.837	0.828	29-01
4	0	0	1	1	0	20	0.777	0.717	02-01,02-02,13-01,23-01,55-02,55-03,62-01
2	0	0	0	1	0	8	0.766	0.665	28-02,33-02,48-02
12	1	0	1	1	0	3	0.691	0.574	72-03
1	0	0	0	0	0	13	0.648	0.517	03-01,07-02,11-01,11-02,17-01,20-01,50-02,54-01,70-01
14	1	1	0	1	?	2	1.000	1.000	
15	1	1	1	0	?	2	1.000	1.000	
7	0	1	1	0	?	2	0.954	0.940	
11	1	0	1	0	?	1	0.917	0.874	
10	1	0	0	1	?	1	0.882	0.829	
5	0	1	0	0	?	1	0.710	0.681	
13	1	1	0	0	?	0	-	-	

#	HLU	DCU	URB	BIG	OUT	n	incl	PRI	DCC
Out = "FALLres", conditions = "BIG","URB","HLU","DCU"									
16	1	1	1	1	1	3	1.000	1.000	
8	0	1	1	1	1	10	0.939	0.931	16-01
3	0	0	1	0	1	4	0.933	0.890	
9	1	0	0	0	1	8	0.885	0.874	10-01
4	0	0	1	1	1	20	0.873	0.835	13-01,55-03,62-01
2	0	0	0	1	1	8	0.869	0.798	28-02
6	0	1	0	1	0	5	0.833	0.824	29-01
12	1	0	1	1	0	3	0.823	0.757	72-03
1	0	0	0	0	0	13	0.772	0.683	11-02,17-01,50-02,54-01,70-01
14	1	1	0	1	?	2	1.000	1.000	
15	1	1	1	0	?	2	1.000	1.000	
7	0	1	1	0	?	2	0.974	0.968	
10	1	0	0	1	?	1	0.914	0.894	
11	1	0	1	0	?	1	0.911	0.868	
5	0	1	0	0	?	1	0.702	0.674	
13	1	1	0	0	?	0	-	-	

Table 8.6: Truth tables - Negative outcome

Out = "~FALLrel", conditions = "BIG","URB","HLU","DCU"								
	HLU	**DCU**	**URB**	**BIG**	**OUT**	**n**	**incl**	**PRI**
1	0	0	0	0	1	13	0.593	0.442
2	0	0	0	1	1	8	0.535	0.335
3	0	0	1	0	1	4	0.525	0.191
12	1	0	1	1	0	3	0.481	0.285
11	1	0	1	0	0	1	0.422	0.126
4	0	0	1	1	0	20	0.410	0.251
5	0	1	0	0	0	1	0.380	0.319
10	1	0	0	1	0	1	0.371	0.091
7	0	1	1	0	0	2	0.271	0.060
9	1	0	0	0	0	8	0.250	0.131
6	0	1	0	1	0	5	0.214	0.172
8	0	1	1	1	0	10	0.195	0.095
14	1	1	0	1	0	2	0.092	0.000
15	1	1	1	0	0	2	0.055	0.000
16	1	1	1	1	0	3	0.039	0.000
13	1	1	0	0	?	0	-	-

Out = "~FALLres", conditions = "BIG","URB","HLU","DCU"								
	HLU	DCU	URB	BIG	OUT	n	incl	PRI
1	0	0	0	0	0	13	0.488	0.290
2	0	0	0	1	0	8	0.471	0.185
3	0	0	1	0	0	4	0.453	0.110
11	1	0	1	0	0	1	0.412	0.132
5	0	1	0	0	0	1	0.384	0.326
12	1	0	1	1	0	3	0.342	0.094
4	0	0	1	1	0	20	0.315	0.111
10	1	0	0	1	0	1	0.257	0.082
7	0	1	1	0	0	2	0.220	0.032
6	0	1	0	1	0	5	0.216	0.176
9	1	0	0	0	0	8	0.206	0.126
8	0	1	1	1	0	10	0.157	0.054
14	1	1	0	1	0	2	0.060	0.000
15	1	1	1	0	0	2	0.056	0.000
16	1	1	1	1	0	3	0.039	0.000
13	1	1	0	0	?	0	-	-

8.7 Solutions

Table 8.7: Conservative solutions

	Out = "FALLrel", conditions = "BIG","URB","HLU","DCU"				
		inclS	**PRI**	**covS**	**covU**
1	DCU*URB*BIG	0.936	0.930	0.177	0.177
2	~HLU* ~DCU*URB* ~BIG	0.887	0.808	0.117	0.117
3	HLU* ~DCU* ~URB* ~BIG	0.887	0.869	0.095	0.095
	M1	0.909	0.886	0.389	
	Out = "FALLres", conditions = "BIG","URB","HLU","DCU"				
		inclS	**PRI**	**covS**	**covU**
1	~HLU* ~DCU*URB	0.864	0.829	0.295	0.032
2	~HLU* ~DCU*BIG	0.839	0.795	0.356	0.093
3	DCU*URB*BIG	0.954	0.949	0.163	0.163
4	HLU* ~DCU* ~URB* ~BIG	0.885	0.874	0.085	0.085
	M1	0.869	0.845	0.636	

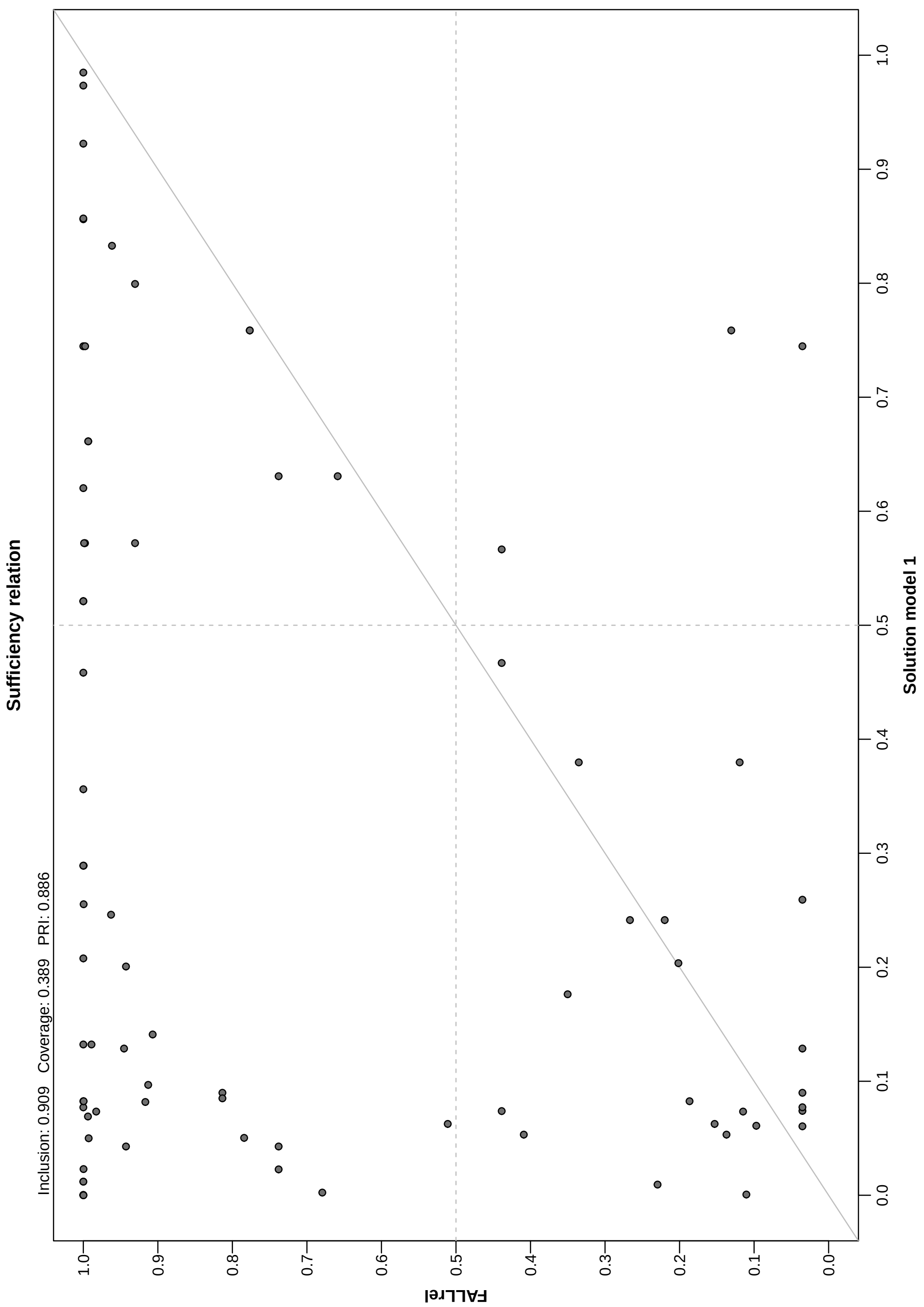


Figure 8.1: XY Plot - Conservative solution - Model 1

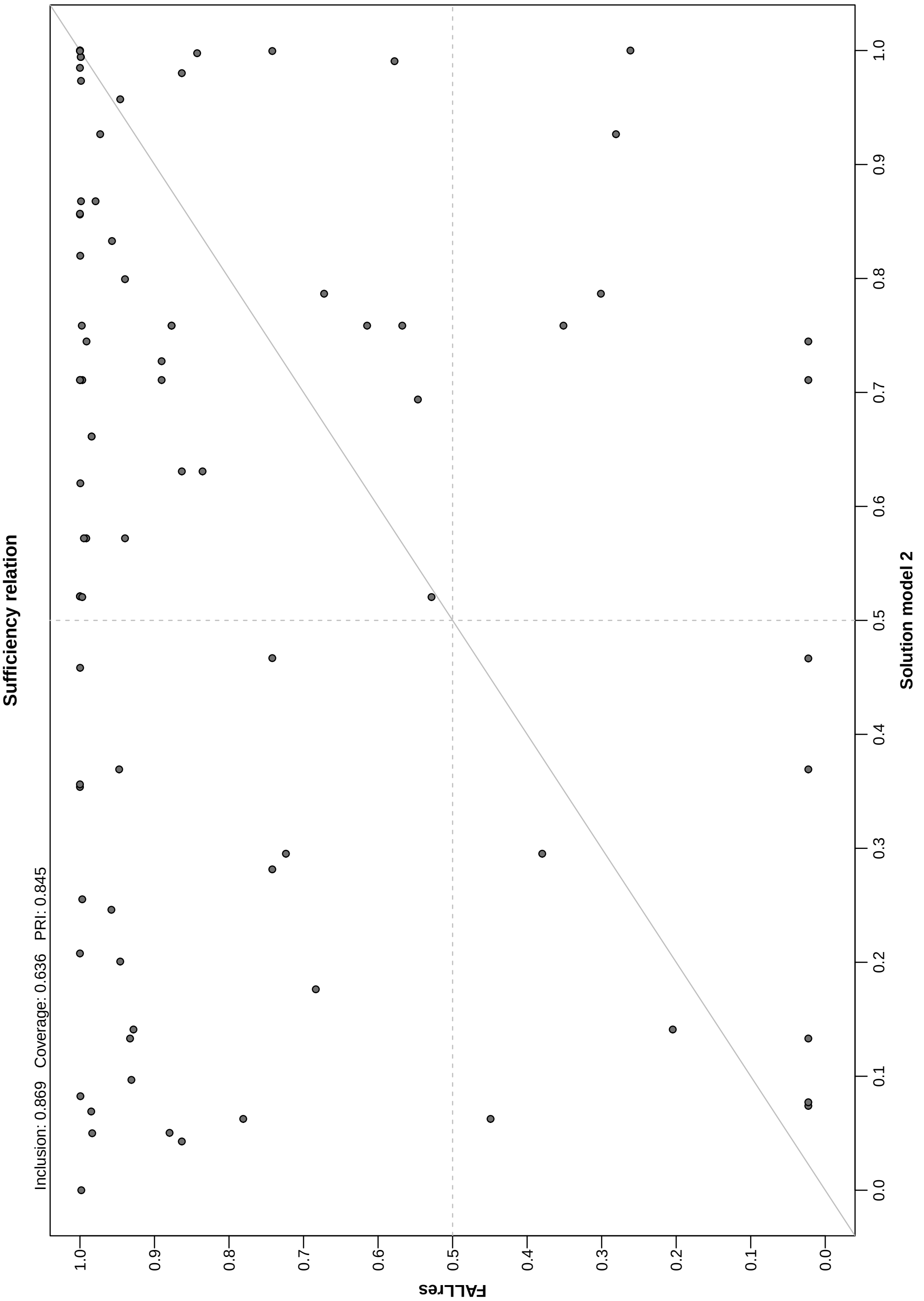


Figure 8.2: XY Plot - Conservative solution - Model 2

Table 8.8: Parimonious solutions

	out = "FALLrel", conditions = "BIG","URB","HLU","DCU"						
		inclS	**PRI**	**covS**	**covU**	**(M1)**	**(M2)**
1	DCU*URB	0.900	0.892	0.222	0.110	0.110	0.123
2	URB*~BIG	0.922	0.887	0.249	0.117	0.124	0.117
3	HLU*~URB	0.881	0.865	0.172	0.045	0.117	
4	HLU*~BIG	0.921	0.909	0.141	0.004		0.076
	M1	0.886	0.862	0.489			
	M2	0.896	0.873	0.448			

	out = "FALLres", conditions = "BIG","URB","HLU","DCU"														
		inclS	**PRI**	**covS**	**covU**	**(M1)**	**(M2)**	**(M3)**	**(M4)**	**(M5)**	**(M6)**	**(M7)**	**(M8)**	**(M9)**	**(M10)**
1	~HLU*URB	0.877	0.852	0.444	0.006	0.182	0.352	0.182	0.352	0.032	0.202	0.032	0.202		
2	HLU*DCU	0.975	0.974	0.105	0.024	0.056	0.056	0.071	0.071						
3	HLU*~URB	0.921	0.915	0.162	0.016	0.114	0.065			0.136	0.087			0.113	
4	HLU*~BIG	0.920	0.911	0.127	0.002			0.094	0.057			0.097	0.061		0.069
5	DCU*URB	0.928	0.923	0.207	0.000					0.031	0.031	0.028	0.028	0.104	0.116
6	URB*~BIG	0.949	0.928	0.231	0.000									0.032	0.026
7	~HLU*~DCU*BIG	0.839	0.795	0.356	0.010	0.093		0.093		0.093		0.093		0.271	0.271
8	~DCU*~URB*BIG	0.878	0.822	0.225	0.000		0.083		0.096		0.083		0.096		

	inclS	**PRI**	**covS**
M1	0.875	0.855	0.756
M2	0.884	0.865	0.746
M3	0.874	0.853	0.736
M4	0.884	0.864	0.738
M5	0.873	0.852	0.731
M6	0.882	0.862	0.721
M7	0.870	0.847	0.693
M8	0.880	0.859	0.695
M9	0.881	0.862	0.731
M10	0.878	0.856	0.687

Table 8.9: Intermediate solutions

Out = "FALLrel", conditions = "BIG","URB","HLU","DCU"

		inclS	PRI	covS	covU
1	HLU*∼ DCU*∼ URB	0.855	0.833	0.120	0.120
2	DCU*URB*BIG	0.936	0.930	0.177	0.177
3	∼ HLU*∼ DCU*URB*∼ BIG	0.887	0.808	0.117	0.117
	M1	0.897	0.872	0.414	
1	DCU*URB*BIG	0.936	0.930	0.177	0.177
2	∼ HLU*∼ DCU*URB*∼ BIG	0.887	0.808	0.117	0.117
3	HLU*∼ DCU*∼ URB*∼ BIG	0.887	0.869	0.095	0.095
	M2	0.909	0.886	0.389	

Out = "FALLres", conditions = "BIG","URB","HLU","DCU"

		inclS	PRI	covS	covU	(M1)	(M2)
1	∼ HLU*∼ DCU*URB	0.864	0.829	0.295	0.032	0.032	0.202
2	HLU*∼ DCU*∼ URB	0.899	0.890	0.114	0.065	0.114	0.065
3	DCU*URB*BIG	0.954	0.949	0.163	0.163	0.163	0.163
4	(∼ HLU*∼ DCU*BIG)	0.839	0.795	0.356	0.010	0.093	
5	(∼ DCU*∼ URB*BIG)	0.878	0.822	0.225	0.000		0.083
	M1	0.872	0.849	0.665			
	M2	0.883	0.861	0.654			
1	∼ HLU*∼ DCU*URB	0.864	0.829	0.295	0.032		
2	∼ HLU*∼ DCU*BIG	0.839	0.795	0.356	0.093		
3	DCU*URB*BIG	0.954	0.949	0.163	0.163		
4	HLU*∼ DCU*∼ URB*∼ BIG	0.885	0.874	0.085	0.085		
	M3	0.869	0.845	0.636			

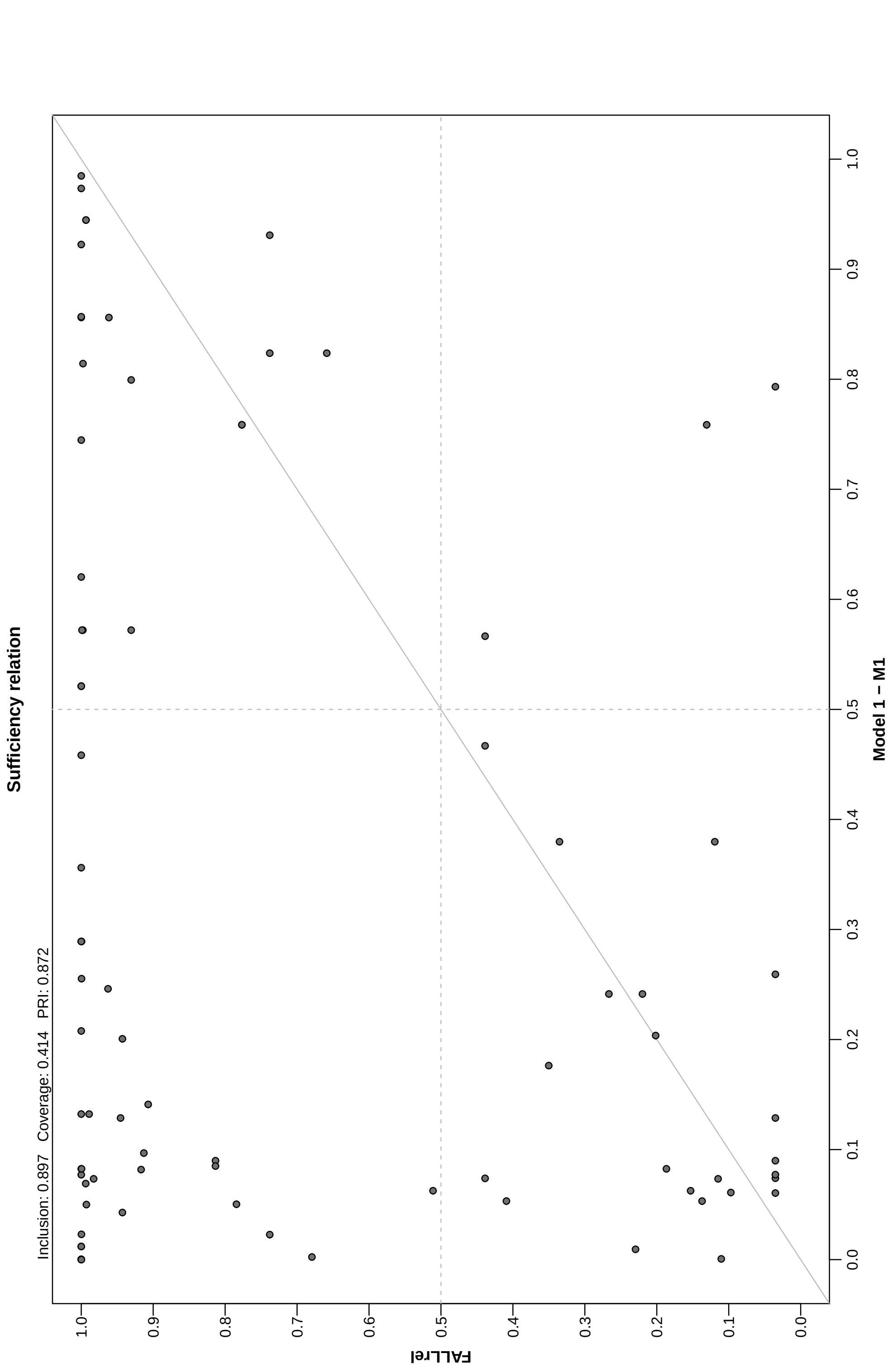


Figure 8.3: XY Plot - Intermediate solution - Model 1 - M1

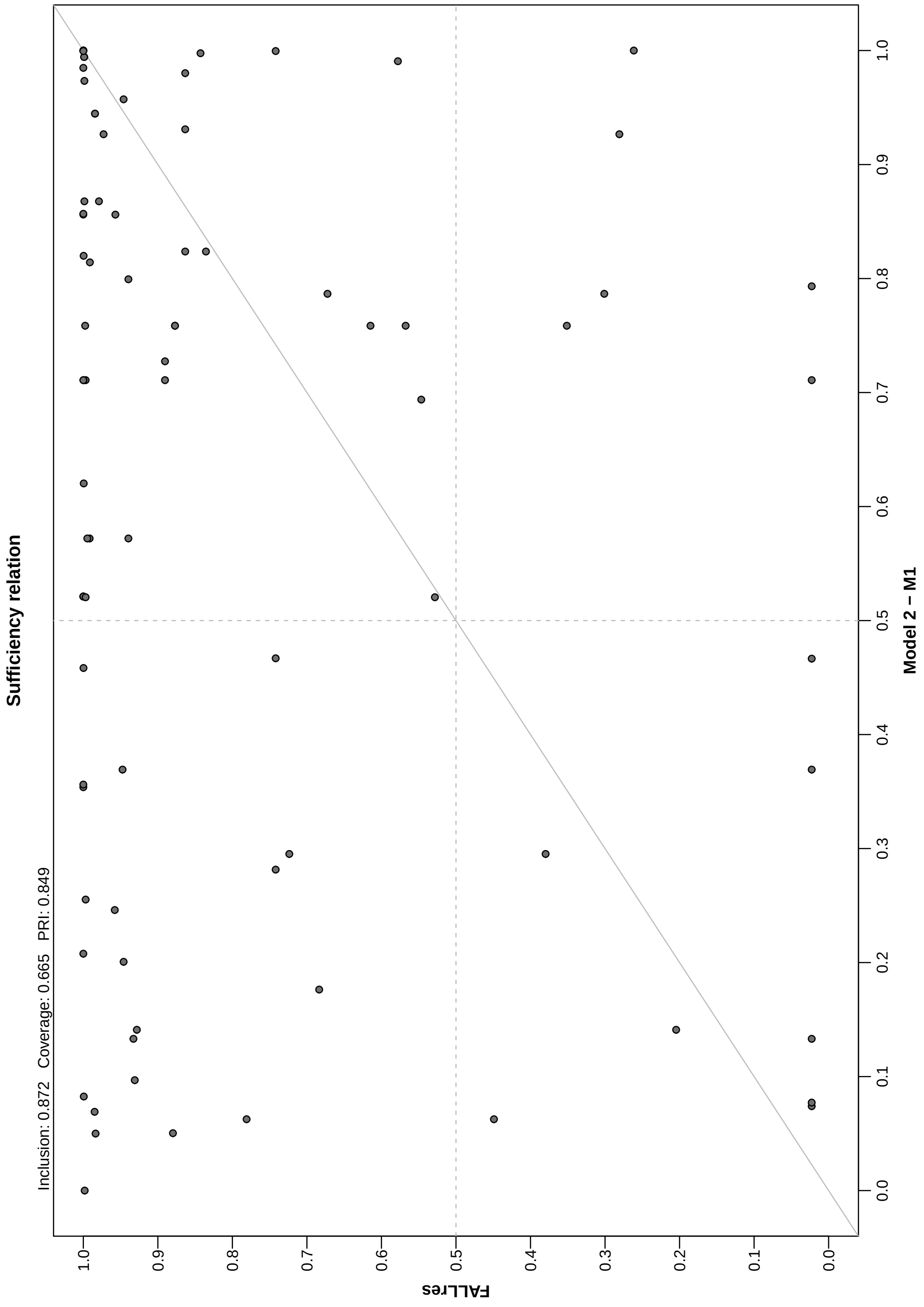


Figure 8.4: XY Plot - Intermediate solution - Model 2 - M1

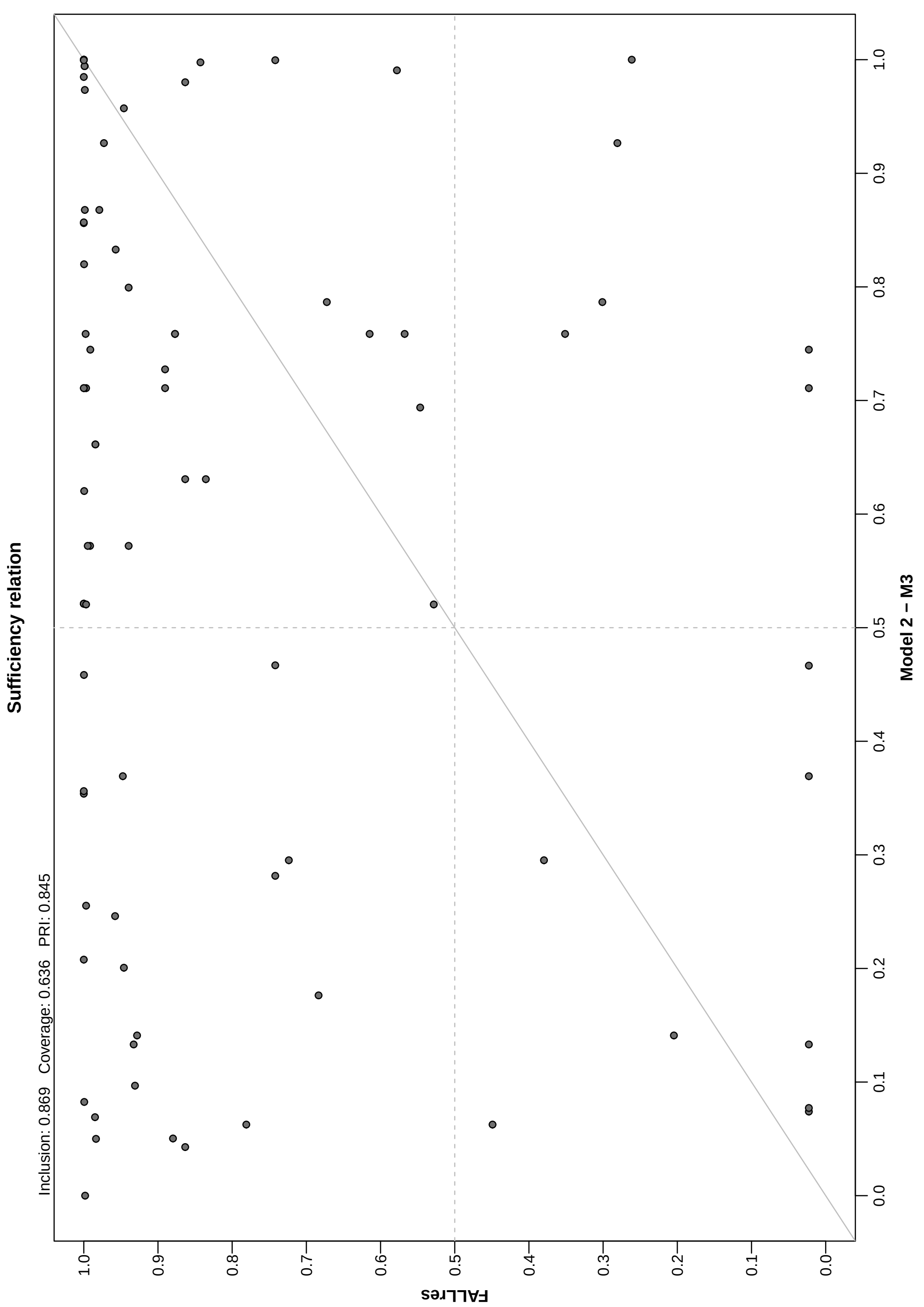


Figure 8.5: XY Plot - Intermediate solution - Model 2 - M2

8.8 Robustness tests

Table 8.10: Results from proportional removal - FALLrel (conservative solution)

FALLrel	original			removal 1			removal 2			removal 3		
configuration	1	2	3	1	2	3	1	2	3	1	2	3
HLU		⊗	●		⊗	●		⊗	●	⊗	●	⊗
DCU	●	⊗	⊗	●	⊗	⊗	●	⊗	⊗	●	⊗	⊗
URB	●	●	⊗	●	●	⊗	●	●	⊗		⊗	●
BIG	●	⊗	⊗	●	⊗	⊗	●	⊗	⊗	●	⊗	⊗
raw consistency	0.936	0.887	0.887	0.936	0.896	1	0.932	0.888	0.886	0.936	0.887	0.887
PRI score	0.930	0.808	0.869	0.930	0.822	1	0.926	0.812	0.869	0.930	0.869	0.808
solution consistency		0.909			0.936			0.906			0.908	
solution coverage		0.389			0.385			0.389			0.395	

Table 8.11: Results from proportional removal - FALLres (conservative solution)

FALLres	original				removal 1				removal 2				removal 3		
configuration	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3
HLU	⊗	⊗		●		⊗	⊗	●	⊗	⊗		●	⊗	⊗	●
DCU	⊗	⊗	●	⊗		⊗	⊗	⊗	⊗	⊗	●	⊗		⊗	⊗
URB	●		●	⊗	●	●		⊗	●		●	⊗		●	⊗
BIG		●	●	⊗	●		●	⊗		●	●	⊗	●		⊗
raw consistency	0.864	0.839	0.954	0.885	0.897	0.862	0.844	1	0.864	0.839	0.893	0.855	0.879	0.870	0.885
PRI score	0.829	0.795	0.949	0.874	0.872	0.825	0.799	1	0.829	0.795	0.867	0.874	0.854	0.839	0.874
solution consistency	0.869				0.869				0.869				0.875		
solution coverage	0.636				0.636				0.649				0.645		

Table 8.12: FALLrel with alternate frequency cut-offs (conservative solution)

FALLrel	n = 2				n=3 (original)			n=4		
configuration	1	2	3	4	1	2	3	1	2	3
HLU			●	●		⊗	●	⊗	●	⊗
DCU	●	⊗	●	⊗	●	⊗	⊗	⊗	⊗	●
URB	●	●		⊗	●	●	⊗	●	⊗	●
BIG	●	●	⊗	●	⊗	⊗	⊗	⊗	●	
raw consistency	0.900	0.910	0.999	0.887	0.936	0.887	0.887	0.887	0.887	0.915
PRI score	0.892	0.862	0.999	0.869	0.930	0.808	0.869	0.808	0.869	0.905
solution consistency	0.901				0.909			0.898		
solution coverage	0.471				0.389			0.342		

Table 8.13: FALLres with alternate frequency cut-offs (conservative solution)

FALLres	n = 2					n=3 (original)				n=4			
configuration	1	2	3	4	5	1	2	3	4	1	2	3	4
HLU	⊗		⊗	●	●	⊗	⊗		●	⊗	⊗	⊗	●
DCU		●	⊗	●	⊗	⊗	⊗	●	⊗	⊗	⊗		⊗
URB	●	●			⊗	●		●	⊗	●		●	⊗
BIG			●	●	⊗		●	●	⊗		●	●	⊗
raw consistency	0.877	0.928	0.839	1	0.855	0.864	0.839	0.954	0.885	0.864	0.839	0.893	0.855
PRI score	0.852	0.923	0.795	1	0.874	0.829	0.795	0.949	0.874	0.829	0.795	0.867	0.874
solution consistency	0.873					0.869				0.898			
solution coverage	0.713					0.636				0.342			

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.

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