A fuzzy-set qualitative comparative analysis of factors influencing successful shared service center implementation

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DOI
10.1108/IMDS-09-2021-0573

Publication date
2022

Document Version
Final published version

Published in
Industrial Management and Data Systems

The current issue and full text archive of this journal is available on Emerald Insight at:
www.emeraldinsight.com/0025-1747.htm

Received 15 October 2017
Revised 7 March 2018
21 May 2018
11 July 2018
Accepted 16 July 2018

Configurations of factors affecting triage decision-making

A fuzzy-set qualitative comparative analysis

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Abstract

Purpose – The purpose of this paper is to explore the configuration of factors affecting the accuracy of triage decision-making. The contribution of the work is twofold: first, it develops a protocol for applying a fuzzy-set qualitative comparative analysis (fsQCA) in the context of triage decision-making, and second, it studies, through two pilot cases, the interplay between individual and organizational factors in determining the emergence of errors in different decisional situations.

Design/methodology/approach – The methodology adopted in this paper is the qualitative comparative analysis (QCA). The fuzzy-set variant of QCA (fsQCA) is implemented. The data set has been collected during field research carried out in the Emergency Departments (EDs) of two Italian public hospitals.

Findings – The results of this study show that the interplay between individual and contextual/organizational factors determines the emergence of errors in triage assessment. Furthermore, there are some regularities in the patterns discovered in each of the investigated organizational contexts. These findings suggest that we should avoid isolating individual factors from the context in which nurses make their decisions.

Originality/value – Previous research on triage has mainly explored the impact of homogeneous groups of factors on the accuracy of the triage process, without considering the complexity of the phenomenon under investigation. This study outlines the need to consider the not-linear relationships among different factors in the study of triage's decision-making. The definition and implementation of a protocol to apply fsQCA to the triage process in EDs further contributes to the originality of the research.

Keywords Fuzzy sets, Qualitative comparative analysis, Heuristics, Individual and organizational factors, Triage accuracy, Triage decision-making

Paper type Research paper

1. Introduction

Nowadays, growing attention is paid to the management of Emergency Departments (EDs), as these healthcare units are continuously affected by overcrowding. This stems from "fewer emergency departments being available for a greater number of patients seeking care" (Stanfield, 2015, p. 396). The triage process is the first step in the path of patients within hospitals' EDs. It consists of the assessment and subsequent prioritization of patients based on the level of severity of their symptoms and their health conditions (Hitchcock *et al.*, 2013). The correct prioritization of patients is crucial, as it has a direct impact on patients' safety and their flow within the healthcare facility (Cioffi, 1998). Moreover, the accuracy of triage assessment affects the ED's level of service quality, as an incorrect sorting implies prolonged waiting-room times, an increased number of patients who leave without being seen, and decreased patient satisfaction (Derlet and Richards, 2000). Furthermore, the accuracy of assessment is often related to the effectiveness of the triage process (Marsden, 2000; Frykberg, 2005). To accurately prioritize patients in a time when available resources are limited

Management Decision
Vol. 56 No. 10, 2018
pp. 2148-2171

0025-1747
DOI 10.1108/MD-10-2017-0999

means, in fact, "to provide care to those who seek it" (Stanfield, 2015, p. 396). These elements justify the increasing attention paid by the literature on healthcare and emergency management (McMillan *et al.*, 1986; Chung, 2005; Andersson *et al.*, 2006; Noon, 2014; Vatnøy *et al.*, 2013; Hitchcock *et al.*, 2013; Martin *et al.*, 2014) to the triage process.

The decision-making process is the foundation of triage practice (Chung, 2005; Noon, 2014). It is frequently described as a dynamic, complex process (Cioffi, 2001; Göransson *et al.*, 2008; Noon, 2014) that occurs mostly under conditions of uncertainty (Cioffi, 1998, 2001) and time pressure (Chung, 2005; Wolf, 2010). Because of these characteristics, some scholars (Cioffi and Markham, 1997; Cioffi, 1998) have classified decision-making in triage assessment as a heuristic process. Tversky and Kahneman (1974), the pioneers of the Heuristics and Biases Program, introduced the term "heuristics," which refers to mental strategies that prevail over the laws of logic and rational choice. Using heuristics, the decision-maker determines systematic deviations from optimal decisions, called "biases," cognitive illusions or "irrationality" (Kahneman and Tversky, 1977, 1981). The Heuristics and Biases Program assumes that heuristics are "mental shortcomings" (Artinger *et al.*, 2015) that always lead to the second-best solution (Kahneman, 2011). This approach has been strongly criticized by Gigerenzer and his research group, who proposed the "fast and frugal" (Gigerenzer *et al.*, 1999) view of heuristics. They argued that heuristics could lead to accurate and fast judgment in complex situations because they focus on a limited number of critical variables, as happens in human reasoning (Gigerenzer 1996; Luan *et al.*, 2011; Meissner and Wulf, 2017). Heuristics are "fast and frugal," as the judgment is based on few cues and is made in a short time (Martignon and Hoffrage, 2002; Kuncel *et al.*, 2011; Drechsler *et al.*, 2014). Central in this view of heuristics is the interplay between the environment's structure and the mental model of the decision-maker. "Heuristics allow for adaptive responses to the characteristics of an uncertain managerial environment" (Artinger *et al.*, 2015, p. 833). The success of a heuristic is determined by its "ecological rationality," namely its match with a specific environment's structure (Gigerenzer *et al.*, 1999). Ecological rationality refers to how a bounded mind "exploits the structure of the social and physical environments in which it must reach its goals" (Chase *et al.*, 1998, p. 212).

The crucial points of the "fast and frugal" approach to heuristics from the perspective of ecological rationality can be also found in triage decision-making, and can be summarized as follows.

The individual, under conditions of uncertainty and limited cognitive and time resources, focuses only on a portion of the available information. The decision can nevertheless be accurate (Gigerenzer and Kurzenhäuser, 2005).

The structure of the information characterizing the decisional situation (task complexity, uncertainty, ambiguity) influences the judgment process and its accuracy (Cioffi, 1998).

The match between the individual experience and beliefs, the social-organizational context in which the decision takes place and the nature of the decisional task are decisive in determining the accuracy of the decision's outcome (Smith *et al.*, 2008).

The assumption of this research, thus, departs from adopting the ecological rationality perspective to frame the decision-making process in triage as a dynamic, complex process, in which factors related to the individual's biography (e.g. education, training, previous work experience) interact with environmental factors (including social-organizational and situational factors) in producing a specific answer to a specific task (Todd and Gigerenzer, 2012).

The literature on clinical and triage decision-making has extensively examined these groups of factors (Stanfield, 2015), separately or via an additive approach. The contribution of our work consists of the development of a methodological approach to analyze, from a non-linear perspective, the effect that combinations of individual and organizational factors have on the accuracy of triage assessment, taking into account the complex nature of the decision-making process and the different levels of uncertainty of situations in which the decision has to be made.

We explore different combinations of factors in terms of their causal link with the level of errors made by triage nurses. This can provide interesting insights into the identification of configurations of levers to foster the accuracy and the quality of the triage process.

The paper is structured as follows: the next section presents a literature review of suggested relevant factors, in terms of their impact on triage nurses' decisions. Section 3 illustrates the main pillars of the adopted methodology, namely the fuzzy-set qualitative comparative analysis (fsQCA), describes the steps of its implementation, and the data collection and elaboration phases. Section 4 reports on the results, while Section 5 discusses them. Section 6 addresses the implications of our findings for theory and practice.

2. Factors affecting decision-making in the triage process

Beginning in the end of the 1990s, several studies have been published, mainly in the field of clinical decision-making and emergency nursing (Cioffi, 1998; Cabana *et al.*, 1999; Croskerry and Sinclair, 2001; Cone and Murray, 2002; Chung, 2005; Andersson *et al.*, 2006; Smith *et al.*, 2008; Garbez *et al.*, 2011; Wolf, 2010, 2013; Martin *et al.*, 2014; Stanfield, 2015) that analyze the decision-making process in the practice of triage. These studies adopt different theoretical approaches and research methods (qualitative or quantitative) and consider different outcomes of the decision-making process. In most cases, the accuracy of the assignment of triage scores to patients is examined as the outcome (Cioffi, 1998; Cooper *et al.*, 2002; Garbez *et al.*, 2011; Martin *et al.*, 2014). Gerdtz and Bucknall (2001) consider the duration of the triage process as the main outcome to be studied. There are also contributions (usually, exploratory, qualitative studies) that focus on the description of the triage assessment process or on the elements considered to make decisions (Chung, 2005; Andersson *et al.*, 2006; Smith *et al.*, 2008).

One of the aspects taken into consideration in studies dealing with the accuracy/vulnerability of the triage process is related to the complexity of the situation that the operator must evaluate (Cioffi, 1998; Chung, 2005; Cioffi, 2001). A shared definition of "complexity" is not traceable in this context, mainly because some studies mention the complexity of the task as an element that can influence the decision, but do not operationalize this concept. Empirical works using a task's complexity as a variable in the analysis of the triage process classify real decisional situations on the basis of two dimensions (Cosier and Dalton, 1988): the uncertainty of the situation and the availability of relevant information. Situations with the lowest complexity are those in which the level of uncertainty is limited and relevant information needed to make decisions is accessible. The most complex situations are those with a high level of uncertainty (limited possibility to predict the value of the decisional variables) and little relevant information available.

The use of objective parameters is one of the most-cited factors in the literature on the triage process (Salk *et al.*, 1998; Gerdtz and Bucknall, 2001; Wolf, 2010; Vatnøy *et al.*, 2013). Objective parameters are vital signs that can be measured through different typologies of diagnostic tests. There is evidence that referring to objective parameters slows down the decision-making process and lengthens the time that the assessment takes (Gerdtz and Bucknall, 2001; Storm-Versloot *et al.*, 2014). The literature does not agree on the effect that the use of objective parameters has on the accuracy of scoring (Conen *et al.*, 2006). On the one hand, vital signs can reveal possible changes in health conditions, improving the accuracy of triage assessment (Burchill and Polomano, 2016). On the other hand, decisions based mainly on vital signs can lead to nurses' under- or over-assessing the assigned priority code (Nakagawa *et al.*, 2003). In a study conducted by Vatnøy *et al.* (2013), it is pointed out that the general tendency of triage operators is to neglect the use of vital parameters. This study also shows that the implementation of protocols and guidelines fosters a reference to objective parameters. Furthermore, as the use of objective parameters increases, the number of patients classified at the highest levels of urgency decreases. Vatnøy *et al.* (2013) claim, however, that the effect of the use of vital signs on the accuracy of the assessment and on patients' safety is not clear. Cooper *et al.* (2002) state that "visual cues (non-verbal communication), physical findings (limited physical examination), and vital signs all inform the decision-making process. Each component likely plays an important part in accurate triage, with the relative importance of each element varying on a case-by-case basis" (Cooper *et al.*, 2002, p. 231). Most experienced nurses tend to under-utilize objective parameters (Chung, 2005). On the other hand, the implementation of specific protocols and guidelines in the ED can lead to an increase in their usage (Vatnøy *et al.*, 2013).

The role of visual cues, protocols and guidelines in determining the decision of triage nurses is also studied (Salk *et al.*, 1998; Cone and Murray, 2002; Cooper *et al.*, 2002; Chung, 2005). Salk *et al.* (1998) look at the same group of nurses assigning a priority code to the same group of patients in a two-stage triage, in which the first stage consists of a telephone triage and the second of a face-to-face triage. The use of formal protocols and objective parameters does not determine an alignment between the scores of the operators in the two phases. This leads the authors to conclude that visual cues become decisive in in-person triage. Guidelines and assignment criteria seem to represent a reference for the decision, especially for beginners, but their presence is not considered decisive in the decision-making process (Salk *et al.*, 1998). In particular, expert nurses perceive the presence of guidelines, pre-established criteria and protocols negatively (Cone and Murray, 2002).

Experience is one of the factors frequently analyzed in theoretical-qualitative studies and in those with a strong empirical and quantitative nature as a fundamental variable, influencing the triage decision-making process and its outcomes. Experience is usually framed as the frequency of nurses' exposure to different emergency problems (Cioffi, 1998). The most widespread measures of the specific experience and skills of nurses are the number of working years in EDs and those accumulated as a triage operator (Cioffi, 1998; Cone and Murray, 2002; Andersson *et al.*, 2006; Martin *et al.*, 2014; Hitchcock *et al.*, 2013). Referring to all the activities performed in EDs, Croskerry and Sinclair (2001, p. 273) claim that "the level of experience of physicians and nurses is intrinsically linked to preventability of error." Hitchcock *et al.* (2013) outline that nurses perceive the level of experience as having an impact on the outcomes of the process and on the professional relationships among staff members. Cone and Murray (2002, p. 203) identify experience as "an important characteristic that included intuition, confidence in judgment, and trust in or reliance on peers." Furthermore, experience in EDs and in triage activities is considered as the primary factor for performing safely in emergency situations. Martin *et al.* (2014) examine whether experience and attitude toward patients are discriminatory when determining accurate assignments of priority codes by nurses in triage. This descriptive study concludes that "findings did not achieve statistical significance to support the notion that attitude or specified amount of experience contributed to accurate ESI score assignment" (Martin *et al.*, 2014, p. 467). Cioffi (1998) analyzes the role of nurses' experience in the mechanisms used to make triage assessment under conditions of uncertainty. First, the results of this work show a variation in the acuity levels assigned by more and less experienced nurses. Second, the perception of assigned acuity levels' accuracy is higher in more experienced nurses than in less experienced ones. This is consistent with other research that relates self-confidence and trust in one's intuitions, courage and the ability to master stress to nurses' work experience (Cone and Murray, 2002; Andersson *et al.*, 2006). Additionally, more experienced nurses usually collect less data when they assess triage cases and use more heuristics, particularly in situations of high uncertainty.

The personal experience of nurses is often characterized as an individual factor in connection with other elements, such as intuition, confidence in one's own assessments, motivation, listening and communication skills and relationships with colleagues and patients (Andersson *et al.*, 2006; Martin *et al.*, 2014). In other cases, experience is related to the level of knowledge acquired through education, formal training and technical know-how in different disciplines (Cone and Murray, 2002; Hitchcock *et al.*, 2013). The "knowledge" variable is a multidimensional concept. In some cases, the level of knowledge is framed in terms of education and training (Chung, 2005; Andersson *et al.*, 2006); in other cases, knowledge is related to broad technical know-how and a diversified knowledge base (Cone and Murray, 2002; Hitchcock *et al.*, 2013). Training activities are considered relevant for reducing triage mistakes (Lampi *et al.*, 2017). Training is also related to the capability of nurses to make decisions coherently with the guidelines of technical triage manuals (Arslanian-Engoren, 2005).

The literature also points to several factors related to the social context and nurses' work environments, which affect the process and potential outcomes of triage (Croskerry and Sinclair, 2001; Wolf, 2010; Hitchcock *et al.*, 2013; Wolf, 2013). Some of these factors refer to the culture and tacit rules in a given context, internalized through experience in the specific work environment and able to affect the perceptions and motivations of nurses. For example, as Wolf (2010) suggests, the culture developed in a context, as well as the perception that operators have of their leaders and the level of collaboration and communication with patients and among peers, can determine the type of information and objective data that nurses take into consideration when assessing priority levels. This also affects their perception of the usefulness of protocols and guidelines. Hitchcock *et al.* (2013) argue that nurses perceive communication, collaboration and the intensity of teamwork as essential to reducing loss of information and ensuring the quality of triage assessment. Croskerry and Sinclair (2001) claim that a lack of feedback by supervisors could compromise the maintenance of ED nurses' cognitive and procedural skills. Wood and Bandura (1989) point out that judgment in decision-making is influenced by motivational mechanisms. If operators have a good perception of the effectiveness of procedures, protocols and guidelines (Greenwood *et al.*, 2000; Smith *et al.*, 2008), they might not feel isolated in their professional responsibility (Adriaenssens *et al.*, 2011; Melby *et al.*, 2011; Vatnøy *et al.*, 2013).

Finally, the literature highlights the potential negative effect of nurses' workload and continuous interruptions of their assessment job (Chung, 2005; Andersson *et al.*, 2006). The ED's overcrowding and patient volume (Hitchcock *et al.*, 2013; Wolf, 2013) could significantly affect the level of stress experienced by triage nurses and, consequently, the accuracy of priority levels' assignment.

All the factors discussed above are summarized in Table I; the table characterizes factors as mainly individual or related to the work environment (organizational or contextual factors), and reports more relevant literature findings about their influence on the triage assessment process.

The studies examined in this short literature review have different objectives and approaches. Some of them are qualitative and aim at highlighting the issues that nurses perceive as important in the triage decision-making process (e.g. Andersson *et al.*, 2006; Hitchcock *et al.*, 2013); others are quantitative and generally study the impact of homogeneous groups of factors on triage outcomes (timing and accuracy of the assignments), with a typically additive approach (descriptive or inferential statistics) (e.g. Gerdtz and Bucknall, 2001; Martin *et al.*, 2014).

Wolf (2010, p. 245), concluding her ethnographic exploration of the clinical decision-making of emergency nurses, claims that the process of acuity assignation observed in her study "seems to be the result of an interplay of elements particular to the individual nurse, the immediate environment of the unit and the general environment of care."

Furthermore, Todd and Gigerenzer (2012), describing the perspective of "ecological rationality" on the heuristic decision-making process, declare: "Our intelligent, adaptive

Factors	References	Individual/organizational and contextual	Main themes and findings
Use of objective parameters	Gerdtz and Bucknall (2001); Nakagawa *et al.* (2003); Chung *et al.* (2005); Vatnøy *et al.* (2013); Storm-Versloot *et al.* (2014)	Individual, affected by the implementation of specific protocols and guidelines and by organizational informal shared rules	Objective parameters are usually under-utilized by nurses, in particular by expert nurses. It is not established how the use of objective parameters could impact on the accuracy of Triage's assessment. The implementation of guidelines and protocols increases the use of objective parameters among Triage's nurses
Use of visual cues	Salk *et al.* (1998)	Individual, dependent also on the complexity of the task to be assessed and by organizational informal shared rules	Visual cues are fundamental sources of information for nurses in in-person triage
Use of formal procedures, guidelines, manuals and protocols, criteria	Salk *et al.* (1998); Cone and Murray (2002); Adrianenssens *et al.* (2011)	Organizational, but also affected by individual attributes	Formal procedures and guidelines represent a reference for young nurses and make them comfortable and safe when making decisions. Pre-established criteria and formal guidelines are perceived as detrimental by expert nurses
Experience	Cioffi (1998), Cone and Murray (2002), Andersson *et al.* (2006), Martin *et al.* (2014), Hitchcock *et al.* (2013)	Individual	The experience affects negatively the use of objective parameters and formal guidelines in making decision. High level of experience impact positively on the intensity of teamwork, on the motivation and on communication with peers and physicians. More experienced nurses use extensively the heuristics in their judgment. It is not statistically proven that greater experience means better accuracy
Knowledge, training and education	Cone and Murray (2002), Chung (2005), Andersson *et al.* (2006), Hitchcock *et al.* (2013)	Individual, dependent in some cases by organizational procedures	A broad technical know-how, acquired through advise by supervisors in other disciplines or by training, could be beneficial for the self-confidence of nurses and, consequently, for the accuracy of acuity levels assignment. Knowledge also contributes to effective communication with peers and patients
Personal traits and attitudes	Andersson *et al.* (2006), Martin *et al.* (2014)	Individual	it is not clearly assessed the direct impact of attitude toward patients, courage, intuition and motivation on the accuracy of the assessment. All these factors are reported as related to the experience of nurses and are classified as personal traits that can contribute to the work environment's climate
Communication, feedback, unit's leadership and teamwork	Croskerry and Sinclair (2001), Wolf (2010), Hitchcock *et al.* (2013), Wolf (2013)	Organizational, but also affected by individual attributes	All these factors can contribute to Triage's assessment accuracy because reduce the loss of information in emergency situations, help in

(*continued*)

Table I. Factors affecting triage process

Table I.

Factors	References	Individual/organizational and contextual	Main themes and findings
			managing the stress and foster the learning process of nurses
Overcrowding, workload, interruptions	Chung (2005), Andersson *et al.* (2006); Hitchcock *et al.* (2013), Wolf (2013)	Organizational-contextual	All these factors affect negatively the accuracy of Triage's assessment, because increases the level of stress in the work environment and eventually produces loss of information

behavior emerges from the interaction of both mind and word" (Todd and Gigerenzer, 2012, p. 4). The "word" is defined as the "structure of the environment," in which and upon which the individual acts. "The environment also influences the agent's actions in multiple ways, by determining the goals that the agent aims to fulfill, shaping the tools that the agent has for reaching those goals, and providing the input processed by the agent to guide its decisions and behavior" (Todd and Gigerenzer, 2012, p. 16). The input to be processed, and the weight assigned to it in the decision, thus become part of the environment and are eventually filtered and interpreted according to individual and social-organizational frames.

The issue addressed in the present paper departs from the premise highlighted by Wolf (2010, 2013), and it is analyzed in accordance with the theoretical perspective of ecological rationality (Gigerenzer *et al.*, 1999).

The research question we aim to answer with this research is:

RQ1. What configurations of factors affect the accuracy of the decision-making process of triage nurses in assigning priority codes?

In answering to this question, we assume the complexity of the phenomenon under investigation and of the information structure of the decisional task (as suggested by the view of "ecological rationality"). The perspective of complexity implies the need to consider that non-linear relationships of different factors play a role in the decisional processes of triage nurses. The methodological approach of qualitative comparative analysis (QCA) seems to be well suited to this aim. To the best of our knowledge, the QCA approach has not previously been used to study the effects of different factors on the accuracy of triage assessment. The present study moreover aims at integrating the repertoire of qualitative methodologies used in the analysis of clinical decision-making; for this reason, the test and calibration of the methodological approach, via two pilot cases, constitutes a relevant objective of the work.

3. Method and data

The QCA is a relatively new approach in the social sciences (Fiss, 2009; Marx *et al.*, 2013; Ragin, 1987; Ragin, 2000; Ragin, 2008) that is receiving increasing attention in managerial studies, as demonstrated by the number of papers using this method that are published in high-quality journals (see, e.g. Dy *et al.*, 2005; Fiss, 2009; Greckhamer *et al.*, 2013; Ordanini *et al.*, 2014).

QCA is a comparative case-oriented (Marx *et al.*, 2013) methodology based on the principles of Boolean algebra and set-theoretic analysis (Ragin, 2008). The method moves from an in-depth knowledge and analysis of a small to intermediate number of empirical cases (e.g. between 5 and 50), toward the identification of configurations of causally relevant conditions linked to the outcome under investigation (Marx *et al.*, 2013).

QCA is case-oriented. The consequence of this view is that the effects of variables are assessed in the context of investigated cases, and not in isolation: cases are framed as configurations of relevant causal conditions. Furthermore, the method is comparative, as it develops through comparisons of cases to find cross-case similarities or differences. Thus, QCA allows researchers to continuously integrate within-cases with cross-cases analysis (Marx *et al.*, 2013). As outlined by Ragin, who launched this methodology and its analytical tools, QCA "integrates the best features of the case-oriented approach with the best features of the variable-oriented approach" (Ragin, 1987, p. 84).

QCA is, in fact, a set-theoretic analytical approach, in the sense that it identifies causal patterns in a phenomenon under investigation by focusing on sets and subsets relationships. The use of set-theoretic principles originates in the awareness that "almost all social science theory is verbal and, as such, is formulated in terms of sets and set relations" (Ragin, 2008, p. 13).

The use of set relations and Boolean algebra to identify and analyze causal patterns that lead to a specific outcome strongly distinguishes QCA from traditional variable-oriented methodologies. In the latter, the verbal relations between sets, typically formulated in social-science theories, are translated into hypotheses of correlations among variables and then studied through correlation techniques (Ragin, 2008). In this kind of approach, variables "aim to capture a dimension of variation across cases and distribute cases on this variation" (Rihoux and Marx, 2013, p. 168). In QCA, a symmetric relationship is divided into two asymmetric analyses, formalized by set and sub-set relationships: one of the necessity of the conditions with respect to the outcome, and the other of their sufficiency. This allows researchers to deal with the complexity of real phenomena, without any *a priori* simplifications. QCA in fact assumes the non-linearity of phenomena under investigation and is based on the principle of causal complexity. This means that, in most cases, it does not make sense to isolate the effect of a single independent variable on the outcome, but configurations of variables are identified that are related to the outcome. Moreover, several different configurations can be recognized as "causal recipes" for the same outcome (Ragin, 1987).

This is one of the advantages in most social sciences of using QCA. Its level of analytical formalization leads to other advantageous features: it is possible to conduct comparative assessments of intermediate samples of cases, that are too big for traditional qualitative approaches and too small for correlation analyses; and the use of Boolean algebra and set operations enables the replication of research conducted through QCA (Rihoux and Marx, 2013).

3.1 The implementation of fsQCA

The QCA research approach has been divided into three different versions based on analytical and software tools (Ragin, 2000; Rihoux, 2006; Cronqvist, 2005): the crisp set (csQCA) version, the version based on fuzzy sets (fsQCA), and the multi-value version (mvQCA).

In this study, the fuzzy-set-based variant is used to consider the granularity of information and data collected during the fieldwork. The possibility to use both fuzzy variables and crisp variables is another reason that makes this method well suited for the context of this study.

The steps suggested to implement the fsQCA are the following:

Identification of relevant empirical cases, causal conditions and outcome.

Building a raw data table. Generally, this table has as many rows as there are cases. Single causal conditions and the outcome are listed in the columns, and cells of the matrix represent the values of indicators through which the causal conditions have been operationalized.

The raw-data table undergoes a dichotomization process in the crisp variant, using thresholds defined by the researcher, based on her/his in-depth theoretical and empirical knowledge (Rihoux and De Meur, 2008). In the fuzzy variant, a calibration process of fuzzy sets representing the causal conditions and the outcome is needed, which again strictly depends on the relevant theoretical and empirical knowledge of the researchers involved (Ragin, 2000).

Building a truth-table. The truth-table groups empirical cases based on the fact that they show the presence or absence of the outcome. In the csQCA variant, the truth-table shows as many rows as there are combinations of causal conditions (2^k rows, where k is the number of causal conditions) and each case is assigned to a unique row. The values in the cells are dichotomous values (0, 1). In the fsQCA version, building a crisp truth-table does not proceed automatically, but requires intermediate steps. In fact, when conditions and outcomes are fuzzy sets, each case can have a unique combination of membership scores assigned to the causal conditions and the outcome. Ragin (2008) shows, however, that there is a correspondence between the rows of the crisp truth-table and the 2^k corners of the multi-dimensional space made by the fuzzy sets.

The analysis of the truth-table allows researchers to identify explicit connections between configurations of causal conditions and the outcome. A causal condition is necessary for an outcome if instances of the outcome constitute a subset of the instances of the causal condition. A condition is sufficient if the instances of the causal condition constitute a subset of the outcome. When fuzzy sets are used, the assessment of sufficiency is not trivial. The solution can be found by applying the logic of fuzzy-sets theory and the operations on fuzzy sets.

To assess the level of fitness of subset relations, two parameters of fit (Legewie, 2013) are used: consistency and coverage. They serve to assess the degree of approximation of identified set-theoretic relations in empirical cases. Consistency measures the degree to which a subset relation between a casual condition and an outcome is "met" in real data (Legewie, 2013). Consistency ranges from 0 to 1, with 1 indicating perfect consistency.

Once the consistency of a subset relation has been assessed, coverage measures its empirical relevance (Legewie, 2013). Coverage also ranges from 0 to 1. As Ragin (2006) outlines, consistency and coverage of a subset relation are contrasting measures in many research contexts, and a trade-off between the two has to be found according to the specific object of investigation, and taking into account the number of causal conditions and available cases. According to Ragin's (2006, 2008) suggestions, in this study the minimum acceptable level of consistency is used to assess the empirical relevance of sufficient sub-set relations (Fiss, 2011), that is, 0.75.

The last step of the QCA procedure is the identification and interpretation of consistent and empirically relevant patterns (causal configurations of conditions) pertaining to the outcome. The analysis of the truth-table is usually employed to identify sufficient combinations of conditions for the outcome to occur. The identification of necessary conditions is an intermediate step implemented to simplify the truth-table (Fiss, 2009). There are three types of solutions that the truth-table analysis provides. A complex solution does not allow for any simplifying assumptions and displays all logically true combinations of factors sufficient for an outcome to occur (Legewie, 2013). A parsimonious solution, instead, is obtained automatically by applying the process of Boolean minimization and all simplifying assumptions to the truth-table, without applying any specific knowledge of the cases under investigation. Finally, intermediate solutions are obtained by allowing for some simplifications and including the researcher's previous empirical and theoretical knowledge in the analysis of the truth-table (Fiss, 2011).

Most of the steps described above are taken with the help of software specifically developed in the context of QCA research. In this study, the package fsQCA 3.0 is adopted. The next section illustrates how the protocol of fsQCA has been implemented in the present research project.

3.2 The application of the fsQCA protocol: field research and data

Field research has been conducted in the EDs of two Italian public hospitals, named Alpha and Beta because of privacy concerns, in the period January–April 2016. The two hospitals are in the same city, but they serve two different populations and significantly differ in terms of the emergency activities' organization. Alpha serves mainly a city population. Beta serves a very large user base, which extends beyond the city's boundaries across the region.

The ED of Alpha is classified as a level I Emergency and Acceptance Department (DEA I). According to the Italian classification of EDs, a DEA I ensures additional services such as patients' observation and short stay. Alpha implemented the triage system in 2008.

The ED of Beta is classified as DEA II. In addition to the services provided by typical first-level DEAs, it ensures the highest-qualifying features related to emergency care, including neurosurgery, cardiac surgery, neonatal intensive care, thoracic surgery and vascular surgery. It introduced the triage system in 2006.

In Italy, triage coding is mostly done on a color-code scale basis, with highest priority given to a red code, followed by yellow, green and white.

Alpha and Beta's EDs exhibit two different organizational models with respect to the prioritization of patients. In Alpha, the whole process is performed in a linear way, without interruptions: the nurse assigned to triage takes care of the patient from her/his entry into the structure until she/he is called for a medical examination (global triage). In Beta, the process is divided into two phases (two-steps triage), each taken charge of by a different nurse. In the first step, the patient is identified and registered, a first evaluation of the expressed symptoms is performed and a temporary codification is assigned by one triage nurse; in the next step, a different triage nurse reassesses the patient and the color-code is definitively assigned, confirming or not confirming the one previously attributed.

During the research period, Alpha's ED employed 31 nurses, of whom 19 were regularly assigned to triage activities; Beta's ED accounted for 59 nurses, 35 of whom were regularly involved in the two steps of triage. In Alpha, triage nurses are those with an adequate basic certification for the execution of the planned activities, who regularly attend specific training courses. In Beta, nurses working in triage are not regularly trained and, in most cases, have not attended specific triage courses. Furthermore, in Alpha's ED there are specific protocols and guidelines available to triage operators; the same does not apply for Beta's ED. The main characteristics of Alpha and Beta's emergency services are summarized in Table II.

Table III reports on the number of training courses (basic and specialized training on triage) attended by the triage nurses of Alpha and Beta's EDs during their working life.

	Alpha ED	Beta ED
Number of accesses in 2015	52,922	90,566
Triage model	Global	Two-steps
Triage shifts	3 shifts (8.00 -14.00; 14.00-20.00; 20.00-8.00)	3 shifts (8.00 –14.00; 14.00-20.00; 20.00–8.00)
Number of triage nurses per shift	2/shift	2/shift (I step) 3/shift (II step)
Re-evaluation of waiting patients	Yes	Yes
Specific protocols and guidelines for triage	Yes	No

Table II. Main characteristics of emergency services in Alpha and Beta

Number of attended courses	Alpha (%)	Beta (%)
⩽2	16	55
⩾3 and ⩽4	68	37
> 4	16	9

Table III. Percentage of attended courses by triage's nurses

Figure 1 shows the distribution of triage nurses' experience levels in the health sector, EDs and the specific ED under investigation for Alpha and Beta's nurses. Furthermore, the average three levels of experience of the two samples are compared (right side of the figure).

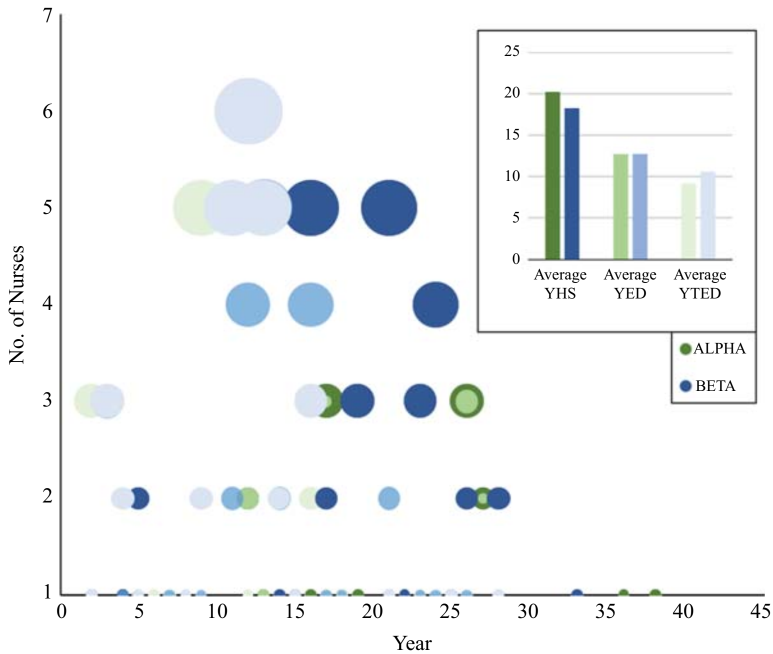
The steps involved in implementing the fsQCA described in section 3.1 have been integrated in the field research.

The first step was conducted as desk research. It was the identification of the outcome (the dependent variable) and the causal conditions to be studied (the factors assumed to have an impact on the outcome). In our study, the accuracy of assigned priority codes represents the outcome of interest. The accuracy is operationalized in terms of the level of errors made by nurses, and is measured as the ratio between the number of errors in the assignment of priority codes and the number of assessed cases by the same nurse.

Most of the studies on factors affecting the effectiveness and quality of nurses' decision-making processes in emergency situations refer to the accuracy of triage decisions and the related error level in the assessment of priority codes as outcome variable (Croskerry and Sinclair, 2001; Martin *et al.*, 2014; Wolf, 2013).

Causal conditions are factors assumed to have an impact on the chosen outcome. The selection of input variables for the research model was made according to the following criteria:

- variables related to different levels of analysis (individual and organizational) were chosen;
- context variables (workload, interruptions, overcrowding) were excluded because the collection of data was executed in a controlled environment (like a laboratory experiment) through a simulative approach; and



Notes: Levels of experience in the health sector (YHS; darker shade of color); levels of experience in emergency departments (YED; intermediate shade of color); levels of experience in the specific emergency department (YTED; lighter shade of color)

Figure 1.
Experience's levels distribution

- other variables, especially those related to personal attitudes (courage, attitudes toward patients) or to the work environment (perception of the unit's leadership), have not been considered due to the unavailability of nurses to disclose information.

Table IV presents the causal conditions and the outcome, specifying, for each variable, the abbreviation and a crisp or fuzzy classification. The choice of calibrating the value of a variable as crisp or fuzzy was based on the typology of the measures adopted and on the level of availability and granularity of information collected in the field. Furthermore, variables representing causal conditions have been classified, according to the literature discussed in Section 2 and consistently with the ecological rationality perspective, as individual-related or organization-related factors.

The use of objective parameters (PO) refers to the tendency of nurses to consider vital signs when choosing priority levels. It is considered an individual factor, because it is dependent on a specific choice of individual nurses, and is often related to their level of experience (Chung, 2005). The years of experience in the health sector (YHS) is included in the study as a proxy for the "knowledge-base" of nurses, together with the number of attended training courses (CT). Moreover, these variables are classified as individual factors, since they can identify different experiences in terms of the education and training of nurses.

The years of experience in EDs (YED) are used as a measure of individual nurses' experience and expertise, as suggested by the literature analyzed in Section 2.

The years of experience in the specific ED under analysis (YTED) is included in this study as a proxy for the nurses' internalization level of organizational formal and informal rules, and of socially constructed norms. In this sense, this variable is classified as an organization-related factor. The perception of the reliability of work procedures and protocols involved in the general triage methodology (PTM) is used as a measure of nurses' attitude toward the use of formal guidelines and criteria established by the Health Ministry. It is considered an individual factor, since it is assumed to be related to individual choices and beliefs, as in the case of objective parameters. The perception of how the triage methodology is adopted in the specific organization (PED) is related to the availability and use of specific formal or informal shared rules in the organizational context of the ED under investigation. Using this perspective, this variable is classified as an organizational factor.

In order to collect the data to be calibrated and used in the fsQCA, 25 patient scenarios were built and administered to triage nurses. Each case simulates a situation in which the patient arrives to the ED. The simulation of clinical scenarios for data gathering is one of the methods used in triage research (Van der Wulp *et al.*, 2008; Gerdtz and Bucknall, 2007), particularly in qualitative and exploratory research.

An expert nurse (a trainer in the triage process) assisted in building patient scenarios. The expert, having obtained specific work experience in triage activities, acted as a trainer

Variable	Acronym	Individual/organizational	Calibration
Use of vital signs and objective parameters	PO	Individual	Crisp
Experience in the health sector	YHS	Individual	Fuzzy
Experience in an emergency department	YED	Individual	Fuzzy
Experience in this emergency department	YTED	Organizational	Fuzzy
Good perception about triage methodology	PTM	Individual	Crisp
Good perception about triage methodology as it is applied in this ED	PED	Organizational	Crisp
Number of attended training courses	CT	Individual	Fuzzy
Errors' ratio	OUTCOME	n/a	Fuzzy

Table IV. Variables in fsQCA analysis of nurses in different hospitals in the region. During the period in which the research was carried out, he was an independent trainer and did not belong to one of the two hospitals under investigation. He elaborated patient scenarios according to his work experience and also relied on his knowledge of real and most frequent triage situations, which were tested in the two EDs.

For each scenario, the triage trainer identified the right priority code to be assigned according to general triage protocols and guidelines. Furthermore, he elicited the key cues that were useful for making correct decisions. Other cues reported in the scenarios' descriptions were considered not necessary for providing the correct answer. To ensure the reliability of patients' scenarios and the priority codes assigned by the expert, scenarios were analyzed by another trainer, operating in a completely different context (Spain). He analyzed the scenarios and assigned them scores. Despite small differences in priority codes' scales in Italy and Spain, the two experts made comparable assessments and defined the same ranking for the patients' scenarios.

We grouped these 25 scenarios into three classes, based on their level of "complexity," following the classification of clinical situations proposed by Cioffi (1998, 2001) based on Cosier and Dalton's (1988): simple cases (the additional cues are compatible with the key cue, relevant information is available and the prediction of decision variables is possible); intermediate cases (the additional cues are not compatible with the key cue and the relevant information is not always available); complex cases (cues are contradictory and some relevant information is lacking). Table V presents the distribution of clinical scenarios in terms of their level of complexity and right color codes.

Nurses involved in the field study numbered 19 for Alpha and 35 for Beta. Thus, all the triage nurses of the two EDs participated in the study. A simulation of prioritization was made, allowing nurses to evaluate, in a very short time (less than five minutes) the information reported in each case, and to assign a priority code (nurses of Beta were invited not to refer to a specific step of the "two-steps" procedure). After that, using a semi-structured interview, nurses were asked to justify their decision, explain the rationale of their choices according to individual and organizational variables selected for the study, and identify the information selected for making the decision. Additional information related to their previous experiences, education, and perception of the working context was collected.

The simulation phase took place for each nurse separately, when she/he was not involved in her/his work shift. Nurses were not informed about the different levels of complexity of patient scenarios presented to them. This choice resembled situations usually experienced by them in real cases.

Raw-data tables (one for Alpha's nurses and one for Beta's nurses) include, for each operator and each of the simulated clinical scenarios, the values of the indicators used to measure causal conditions and the outcome. Table VI shows the variables and the typology of measures obtained through the interviews.

The calibration of fuzzy sets was executed automatically by the software R, based on data and using qualitative anchor points provided by the investigators.

The elaboration and analysis of truth-tables, instead, were performed through the fsQCA 3.0 package.

Table V. Classification of cases with respect to their level of complexity and to their color codes

	White priority code	Green priority code	Yellow priority code	Red priority code	Total
Simple	4	6	0	3	13
Intermediate	0	0	6	0	6
Complex	1	3	2	0	6
Total	5	9	8	3	25

4. Results

Results of the application of fsQCA are reported with reference to the two analyzed samples (Alpha's nurses and Beta's nurses) and to the three categories of clinical scenarios under analysis: simple, intermediate, and complex (Table VII). Complex solutions have been chosen for the analysis of truth-tables, as the present research is exploratory: its aim is the identification of all consistent and/or empirically relevant combinations of factors leading to the outcome, to be further investigated or simplified through additional case studies (other EDs). The analysis' focus on sufficient configurations follows the assumption that the triage-decisional process is complex, and diverse combinations of causal conditions can be linked to the occurrence of the same outcome.

As shown in Table VII, none of the emergent configurations for Alpha's sample passed the consistency test (threshold 0.75) in the case of simple scenarios. This result is probably due to the fact that, in simple cases, the coherence between the cues determines a lower level of errors than in intermediate and complex ones.

This means that it is difficult to find cases in which the subset relation between causal configurations and the outcome (presence of a certain level of errors) is verified. Despite this fact, there is almost one solution related to Alpha's sample that is close to the consistency threshold and that also exhibits a balance between consistency and row coverage.

The third solution's row (PO*YHS* ~YTED*PED*PTM*CT) presents a consistency of about 0.725 and a row coverage of 0.4. This sufficient configuration shows that the recurrent use of object parameters as vital signs (PO), long experience in the health sector (YHS), a lack of specific experience in the ED under investigation (~YTED) combined with a good perception of the reliability of the triage methodology (PTM) and of its implementation (PED), and with a high level of training on triage (CT), together lead to the occurrence of errors in the assessment of priority codes by Alpha's triage nurses in simple scenarios. It seems that the reliance on vital signs and the good level of knowledge of nurses, acquired through both work experience in the health sector and training courses attended, produce an overconfidence of personnel that, in turn, is conducive to making mistakes. Another individual factor also contributes to this overconfidence: nurses' perception of the robustness of guidelines provided by the general protocols of triage methodology.

The first solution displayed in Table VII for Alpha, in simple scenarios (PO*YHS*~YED ~YTED*PED*PTM), with a consistency of about 0.70 and a coverage slightly higher than the third solution's row, partially confirms the result that emerged above. This solution shows that a limited or lacking work experience in EDs implies a susceptibility to errors, despite a prolonged working history in other health operative units and the perceived reliability of triage protocols.

The Beta sample's results related to simple scenarios (Table VII-first box on the right side) show substantial differences compared to what was just reported in the case of Alpha.

Variable	Measure
PO	1 if the decision has been made using vital signs 0 if the decision has been made without using vital signs
YHS	Number of years of experience in the health sector
YED	Number of years of experience in an ED
YTED	Number of years of experience in this specific ED
PTM	1 if the operator declares to be confident in the Triage methodology 0 if the operator declares to be not confident in the Triage methodology
PED	1 if the operator declares to be confident in the Triage methodology as it is applied in the specific ED 0 if the operator declares to be not confident in the Triage methodology as it is applied in the specific ED
CT	Count of attended training courses on triage

Table VI. Variable in the fsQCA analysis and their measure

Table VII. Results of fsQCA in simple, intermediate, and complex clinical scenarios both for Alpha and Beta emergency departments

	Alpha				Beta		
Configuration	RAW COVERAGE	UNIQUE COVERAGE	CONSISTENCY	CONFIGURATION	RAW COVERAGE	UNIQUE COVERAGE	CONSISTENCY
Simple							
PO*YHS*~YED*~YTED*PED*PTM	0.442105	0.0547369	0.697674	~PO*YHS*YED*YTED*~PED*~PTM*CT	0.0392402	0.0392402	1
PO*~YED*~YTED*PED*PTM*CT	0.393684	0.00631577	0.653846	PO*YHS*YED*YTED*~PED*PTM*CT	0.172524	0.137345	0.717517
PO*YHS*~YTED*PED*PTM*CT	0.406316	0.0189474	0.725564				
~PO*~YHS*~YED*~YTED*~PED*~PTM*CT	0.0652632	0.0652632	0.54386				
Solution coverage			0.532632	Solution coverage			0.176586
Solution consistency			0.575	Solution consistency			0.765574
Intermediate							
PO*YHS*~YED*~YTED*PTM*~CT	0.472258	0.104516	0.831818	~PO*YHS*~YTED*PED*PTM*~CT	0.137203	0.0764015	0.918954
PO*~YED*~YTED*PED *PTM*CT	0.296774	0.0309677	0.804196	PO*YHS*YED *YTED*PTM*~CT	0.114192	0.0651566	0.993228
PO*YHS*~YTED*PED*PTM*CT	0.265806	0	0.774436	~PO*~YHS*~YED*~YTED*PED*PTM*CT	0.111387	0.0548768	0.938837
~PO*~YHS*~YED*~YTED*~PED*PTM*CT	0.211613	0.211613	0.811881	PO*YHS*~YED*~YTED*~PED*PTM*CT	0.0497569	0.0124166	0.984593
PO*YHS*YED*YTED*~PED*PTM*CT	0.154839	0.0258064	0.736196				
Solution coverage			0.767742	Solution coverage			0.306993
Solution consistency			0.750315	Solution consistency			0.938447
Complex							
PO*~YHS*~YED*~YTED*~PED*CT	0.217628	0.0620239	1	~PO*YHS*YED*YTED*~PED*~PTM*CT	0.0278783	0.0278782	1
~YHS*~YED*~YTED*~PED*PTM*CT	0.309032	0.0261153	0.879257	PO*YHS*YED*YTED*~PED*PTM*~CT	0.172524	0.172524	0.946586
PO*~YHS*~YED*~YTED*PTM*CT	0.311208	0.0772579	0.953333	~PO*YHS*YED*YTED*PED*PTM*~CT	0.249273	0.249273	0.958017
~PO*YHS*YED*~YTED*~PED*PTM*~CT	0.198041	0.0707291	0.764706				
PO*YHS*YED*YTED*~PED *PTM*CT	0.09358	0.0304679	1				
PO*YHS*YED*~YTED*PED *PTM*CT	0.085963	0.00761694	0.918605				
Solution coverage			0.635473	Solution coverage			0.449675
Solution consistency			0.870343	Solution consistency			0.956075

There is a solution that achieves the highest level of consistency, although the degree of coverage does not display a high empirical relevance. The fact that we can identify a solution with a high level of consistency (simple scenarios) in the case of Beta, unlike the case of Alpha, can be interpreted in accordance with what was previously assumed. In Alpha, in the case of simple scenarios, the level of correct codes assigned by the operators is equal to 75.45 percent; in the case of Beta, more errors are identified (64 percent of correct codes).

The first row of Table VII for Beta's sample in simple scenarios (~PO*YHS*YED*YTED*~PED*~PTM*CT) shows that, in Beta's ED, the high level of errors can be explained by the lack of reference to objective information (~PO), associated with a high level of experience in the health sector (YHS) and in EDs (YED, YTED) and with low confidence in the robustness and reliability of triage methodology (~PTM), including how it is applied in the specific ED (~PED). The theoretical knowledge acquired through attending training courses (CT) also seems to be detrimental.

To interpret these results, we can recall some organizational characteristics of Beta's ED. The triage is normally performed in two steps, and the use of vital parameters is often postponed from the first phase to the second phase; Beta's triage operators exhibit a slightly higher seniority than those of Alpha in the specific ED. Finally, in Beta there are no specific protocols and guidelines on how to implement the triage. In simple cases, the available information is limited and unambiguous and the use of objective elements should lead to the correct solution. Instead, in the case of Beta, nurses tend to neglect the measurement of vital parameters, especially in clinical cases classified as "simple," because of practices acquired in the specific organizational context; it seems that there is an excessive recourse to basic theoretical knowledge and to experience gained in the field that, when associated with a lack of confidence in manuals, procedures and ministerial protocols, leads to errors.

In intermediate scenarios and for Alpha's sample, four configurations are displayed that passed the consistency test and that exhibit an acceptable level of coverage.

The most consistent configuration for the Alpha sample (PO*YHS*~YED*~YTED*PTM*~CT) is also the most empirically relevant in the set of intermediate clinical scenarios. This solution reinforces some of results discussed for simple scenarios. Looking at all the configurations that emerged as solutions for Alpha, and in the case of intermediate clinical scenarios, it can be observed that the weak experience in EDs (~YED, ~YTED) and the lack of coherence among cues are compensated for by an overconfidence of nurses in the general guidelines available in the triage methodology (PTM). But this kind of behavior is not beneficial to the effectiveness of triage implementation.

Referring to Beta in intermediate complex scenarios (Table VII-second box on the right side), it can be noticed immediately that all the solutions passed the consistency test.

The solution with the highest consistency (PO*YHS*YED*YTED*PTM*~CT) shows that, in intermediate scenarios, errors are mainly related to a reliance on objective parameters (PO) and work experience (YHS*YED*YTED), accompanied by operators' reference to general guidelines (PTM) and non-adequate theoretical knowledge acquired through training (~CT). The experience of Beta's nurses seems to be the major driver of assessment errors, together with little attention to formal training.

With respect to complex scenarios and Alpha's sample, there are six emergent configurations representing sufficient conditions for the occurrence of the outcome. All the identified solutions present a consistency above the suggested threshold. The coverage, as expected, is noticeably less than in the cases discussed above for Alpha's sample.

The configurations that exhibit a consistency equal to 1 (PO*~YHS*~YED*~YTED*~PED*CT; PO*YHS*YED*YTED*~PED*PTM*CT) reveal that the high propensity of nurses to consider the objective parameters (PO) in the assessment of priority codes, associated with a high number of attended training courses (CT), and with a lack of confidence in the specific triage guidelines of the ED under investigation (~ PED), are susceptible to errors in complex scenarios for Alpha. Furthermore, as shown in the second, third, fifth and sixth rows of the last box of Table VII (left side), the combination of an intense perception of the effectiveness of the general triage methodology (PTM) and a high number of training courses (CT) attended probably determines nurses' strong recourse to theoretical knowledge, without considering other information and informal rules provided by the specific work context. Additionally, the use of vital signs to make decisions (PO) is present in most of the highly consistent solutions (rows 1, 3, 5, 6 of table VII- third box on the left side), as is the lack of experience in the specific ED. This is also true for simple and intermediate clinical scenarios.

Finally, the third box on the left side of Table VII reports three complex solutions that emerged from the elaboration of data referring to Beta's nurses in complex scenarios. All these configurations show a consistency above the threshold and an acceptable level of coverage. The solution with greater consistency (~PO*YHS*YED*YTED*~PED*~PTM*CT) shows that Beta's triage operators commit mistakes in complex scenarios when they rely too much on their knowledge base (YHS, CT), and their experience in EDs and in the specific ED (YED*YTED), paying limited attention to objective parameters (~PO) and lacking confidence in triage methodology and how it is applied in the specific context under analysis (~PED*~PTM). Another solution, with high consistency and with a level of coverage, emerges, higher than the solution examined above (~PO*YHS*YED*YTED*PED*PTM*~CT). In this case, the Beta operators seem to rely mainly on their experience and confidence in the general and organizational rules (even if these are unwritten rules, because Beta does not have specific protocols and guidelines). Also, in this case as in the previous one, triage nurses do not rely very often on vital parameters. In the case of the first solution examined (with a consistency of 1 and a very low coverage), the error is determined by the high experience in the field and the theoretical knowledge acquired through training courses; in the case of the second examined solution, the error seems to be determined again by recourse to individual work experience and also by a reference to formal (PTM) and informal rules (PED) available in Beta's ED. It is interesting to note that, in the case of Beta's sample, the solution with the highest consistency in simple scenarios is also one of the solutions with higher consistency in complex ones: (~PO*YHS*YED*YTED*~PED*~PTM*CT).

5. Discussion

The results described in the previous section lead to three relevant findings, representing the main contribution of this research to the scientific debate on the decision-making process in triage.

First, factors usually analyzed by the literature as elements characterizing the triage process cannot be isolated from each other when assessing their impact on decision-making outcomes. Groups of homogeneous factors (knowledge and experience, recourse to objective parameters and guidelines, perception of the reliability of guidelines, protocols and informal rules of the organization) combine with each other and do so differently in the two organizational settings under investigation.

This is in line with what emerged from the analysis of the literature summarized in Table I. Numerous studies highlight, through a descriptive approach, that the experience of nurses affects the intensity of their use of vital parameters (Chung, 2005; Vatnøy *et al.*, 2013). The implementation of protocols and guidelines determines a greater use of vital parameters (Gerdtz and Bucknall, 2001); furthermore, the high level of nurses' experience fosters a climate of nursing satisfaction and greater trust (Andersson *et al.*, 2006). On the other hand, the literature is unable to assess in a definite way the impact of single or homogeneous factors on the outcomes of the triage process. For example, it has not been established whether a high level of nurses' experience positively affects the accuracy of acuity levels' assignments (Martin *et al.*, 2014). This lack of statistical evidence could be explained by the complex adaptive nature of the decisional process (deMattos *et al.*, 2012), which requires more attention to non-linear relationships that occur between factors related to different levels of analysis (individual, groups, organization). From the methodological point of view, this implies avoiding traditional variable-oriented (Ragin, 1987) approaches, adopting linear and additive perspectives (e.g. linear regression, factor analysis).

Second, results clearly show no single pattern is able to explain the emergence of errors. We can observe that there are regularities in the configurations of factors leading to a high level of mistakes, and that these regularities are different in the two organizational contexts analyzed. In the case of Alpha's sample, the reliance on objective parameters (particularly for beginners), the scarce experience in the specific ED and in Emergency, and confidence in the effectiveness of triage protocols and guidelines are mainly related to the highest levels of errors. In practical terms, it emerges clearly in Alpha the need of achieving a balance between the level of work experience in Emergency and the level of work experience in other areas of healthcare. This result could be reached by structurally revising recruiting policies or by designing specific training on the job initiatives for beginners of triage.

In the case of Beta, instead, the scarce recourse to objective parameters and the high amount of work experience, particularly in the specific ED, are related to the generation of assessment mistakes. In some cases, the effect of these elements is amplified by a reference to general protocols and a lack of confidence in the specific organizational rules (shared informal rules). The managerial levers to be considered for reducing errors in this context, above all in simple cases, could involve training interventions aimed at sensitizing expert operators to consider the vital parameters more carefully. The creation of local guidelines, which underline the importance of certain objective variables, could be a further element to consider.

The finding above can be traced back to the research of Wolf (2010), which emphasizes the importance of organizational rules (formal and informal) in determining the ways in which nurses seek and assign meaning to the information used to make decisions. Decisions are an output of the interplay between nurses' individual frames and frames socially shared in a specific organizational context. It also confirm the assumption of this research, using the perspective of ecological rationality of Gigerenzer *et al.* (1999) on heuristics, and helps us in discussing the third relevant finding of our study.

In each of the considered EDs, the configurations of factors leading to errors show specific regularities that seem to be not strictly dependent on the level of complexity of simulated tasks. The specificity of the decisional situations disappears in the face of the specificity of organizational environments. The "complexity" of medical scenarios in our study represents what Todd and Gigerenzer (2012) name "the structure of the information" of situations assessed by nurses. The complexity, in fact, is characterized in terms of level of uncertainty and the availability or redundancy of information. Todd and Gigerenzer (2012) however highlight that "the situation" is conveyed or filtered by the environment. Individuals choose to consider one piece of information rather than another, or give weight to one piece of information rather than another, based also on behaviors and rules that are collectively shared in the environment in which the decision is made. Our results, therefore, remind us of the need to consider the complexity of the task in light of the constraints and resources that characterize the specific organizational context in which nurses work.

In summary, our findings suggest that no single factors (or homogeneous groups of factors) could explain the outcomes of decision-making in triage assessment alone. Factors related to different levels of analysis (individual, group, situation, organization) have to be analyzed together, adopting a perspective that is able to take into account their complex interaction and the non-linearity of their relationships as well as the outcome of the decision-making process. This opens up a new perspective for research and practice.

6. Conclusions

This paper addresses a topic widely analyzed by the literature on clinical decision-making: the identification of factors influencing triage nurses' decision-making process and the evaluation of their impact on triage outcomes. The work's innovative contribution to the debate is twofold.

First, the analysis of factors impacting triage decision-making was framed using the perspective of ecological rationality, proposed by Gigerenzer *et al.* (1999), to explain the performance of fast and frugal heuristics. This perspective informs Wolf's research (2010, 2013), although not explicitly, and outlines the need to consider nurses' decision-making in triage as a complex process, in which different elements at different levels of analysis (individual, organizational and environmental) interact and co-evolve in determining process outcomes. In other healthcare contexts, where decision-making processes are characterized by uncertainty and time pressure, the perspective of ecological rationality on heuristics is present (see for example: Rudolph *et al.*, 2009) and drives researchers to model decision-making processes as complex, adaptive and path-dependent. The findings of this paper could be applied in these different healthcare empirical settings as well, in order to shed light on the interplay of factors affecting the accuracy of decisional processes.

Second, in accordance with the theoretical premise, the paper adopts a qualitative methodology that allows for integrating the richness of case-oriented approaches with the formalization of variable-oriented approaches (Ragin, 2006). To the best of our knowledge, this is the first application of QCA to the topic under investigation. The paper has, thus, contributed by proposing a methodological approach that preserves the specificity of the analyzed cases and their intrinsic complexity, without resorting to reductionist hypotheses.

The main findings of the study suggest some implications for research. Errors in the assignment of triage priority codes are determined by the interplay between different factors, some relating to the individual level and others related to the organizational level. These groups of factors interact and co-evolve, determining specific answers to specific situations, these latter being filtered and interpreted in the light of the constraints and resources of the context in which the decision is made. It is therefore necessary to not isolate individual factors from each other and from the organizational and contextual ones in the analysis, and to avoid linear and additive approaches. The perspective inspired by the theory of Complex Adaptive Systems (Holland, 2006) could be particularly suitable for this issue. In Complex Adaptive Systems, individual agents interact in a specific environment, characterized by opportunities and threats, following their local rules and preferences ("internal models" or "micro-specifications") and co-evolving with the environment itself. Their interactions are not linear and determine the emergence, at the collective level, of macro-regularities that cannot be explained by completely deconstructing the system and studying the local behaviors of agents. To identify possible explanations for aggregated properties, it is necessary to adopt a "generative" approach (Epstein and Axtell, 1996), using methodologies that are able to identify sets of micro-specifications sufficient to explain the emergence of the collective outcome. In this study, the exploratory analysis has been conducted through fsQCA, which allowed us to outline different patterns of factors that determine the emergence of errors. Based on this result, further developments of the research could be proposed in order to develop an agent-based model, calibrated through empirical data. This model would be useful to evaluate the impact of additional contextual factors and assess ex-ante the effect of some managerial interventions on the accuracy of decision-making processes, in triage and in other healthcare contexts in which uncertainty and time pressure make decisional processes complex, dynamic and adaptive.

This complexity could also inspire managerial practice. The interventions aimed at improving the effectiveness of triage practice and clinical decision-making in general should be designed while avoiding two deviations: hard managerial approaches (acting on formal rules, procedures and structure) and soft approaches (focused on the motivation of people) (Morieux and Tollman, 2014). Managerial interventions should emerge instead from an in-depth knowledge of the organizational context and decision-making situations, and be aimed at fine-tuning the relationships between individuals and contextual resources and constraints.

Some limitations affect this study. First, it was not possible to include contextual factors such as ED's overcrowding, patients' volume, the effect of interruptions in the analysis; factors which can determine an increase in the level of operators' stress and a potential loss of information at the time of the decision (Hitchcock *et al.*, 2013; Wolf, 2013).

Furthermore, the absence of the patient at the moment of data collection prevented a verification of the role of visual cues in the decision-making process. Both these limitations derive from the use of a simulative approach in the data collection step. This choice was dictated by the need to analyze the impact of situations characterized by different levels of complexity and, at the same time, to keep research time limited. Some measures have been adopted to make the simulations closer resemble reality and increase the confidence of the researchers about the results' interpretation: the data collection phase was preceded by a period of observation in the field; limited time was given to the operators to assign priority codes to the analyzed scenarios, as happens in real situations; immediate interaction with other nurses was avoided, as occurs during each work shift; and finally, scenarios proposed to nurses were enriched with information regarding the presentation of the patient at the door.

Future research will revolve around adapting the protocol used during the fieldwork in order to carry out a structured observational study during the situations experienced by nurses in the two organizational settings that were investigated. By comparing the results, it will be possible to carry out a precise assessment of the implications of the simulation approach.

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