ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

ARTIFICIAL INTELLIGENCE

MASTER THESIS

in

Ethics in Artificial Intelligence

ARTIFICIAL INTELLIGENCE IN CHILD ABUSE AND NEGLECT: A PILOT STUDY ON ETHICAL CONSTRAINTS AND OPPORTUNITIES

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Academic year 2024-2025

Session 1st

dedicado a quien sigue siempre.

Abstract

According to the latest national investigation carried out by the Guarantor Authority for Childhood and Adolescence (Autorità Garante per l'Infanzia e l'Adolescenza) the cases of maltreatment of children and adolescents have increased by 58% in five years [5]. The need to have an effective tool and system for the early identification of abuse and maltreatment led Sant'Orsola's doctors to propose a collaboration with the Artificial Intelligence department of the University of Bologna to study the possibility of including AI technology to tackle this problem.

In this thesis, after researching known solutions, we performed rule-extraction on the professional manuals provided by the doctors. The manuals describe the symptoms that can be found in the patients at risk, along with the behavior that the doctor should have during the patient-doctor interaction and the steps that the doctor and the hospital should follow.

After extracting the rules, we analyzed, restructured and summarized them into questions. We studied two important instruments, ESCAPE and SCAN, that were born with the same aim as our project and compared our questions with the questionnaires described in these two studies.

This project resulted in the creation of a 5-item checklist that is designed to assist the medical professional that encounters an at-risk patient to determine whether the child could be a victim of abuse or maltreatment.

In the future, the aim is to incorporate this tool as a standard step during any clinical consultation of a minor, in order to drastically reduce the cases of maltreatment and abuse of children and adolescents in Italy.

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Chapter 1

Introduction

Artificial Intelligence (AI) is increasingly being proposed as a transformative tool to support clinical decision-making across a wide spectrum of medical domains [1]. From radiological imaging to predictive diagnostics, AI-based models have demonstrated promising capabilities in extracting insights from large volumes of health data. However, the question remains whether AI should be applied indiscriminately across all domains, particularly in sensitive and ethically complex contexts such as the identification of child abuse and neglect [14].

This thesis investigates the applicability and limitations of AI in the context of child abuse and neglect detection, through a pilot study utilizing retrospective emergency room (ER) data from a pediatric hospital in Italy. The dataset includes a clinically significant variable: the presence of the code "NAP" (Neglect and Abuse Pediatric), which is entered by healthcare professionals in cases of suspected abuse or neglect. Although the development of AI-based predictive models for such classification tasks might initially appear promising, a deeper ethical and methodological analysis—conducted using the AEQUITAS "Zero-question methodology" [15]—challenges this assumption. The AEQUITAS framework is designed to assess the appropriateness of

AI implementation before model development begins. It encourages the involvement of a multidisciplinary panel comprising domain experts (e.g., pediatricians and child protection specialists), legal scholars, social scientists, AI technical experts, and directly affected stakeholders—in this case, the physicians responsible for data entry and interpretation. Through this deliberative and structured process, it was collectively concluded that the dataset under examination fails to meet several critical preconditions—ethical, statistical, and contextual—that would justify the use of AI for predictive purposes. There are several critical concerns. The number of NAP cases is too small to support statistically robust and generalizable predictions. Moreover, the human and social implications of falsely classifying a case as abuse—or failing to do so—are too high to rely on models that are inherently probabilistic and potentially biased. Therefore, this study reframes the use of AI not as a tool for prediction, but as a means of augmenting the clinician's capacity to recognize potential signs of abuse or neglect through knowledge support.

The core research question of this thesis becomes: How can AI be used responsibly and ethically to support, rather than replace, human judgment in child protection? Existing medical guidelines and manuals already provide criteria to help clinicians identify cases of suspected abuse and neglect. However, these documents are often extensive, dense, and difficult to process in real-time during clinical decision-making. To address this, the second part of this thesis explores the use of large language models (LLMs) to extract computable rules from established medical guidelines. The objectives are twofold:

1. Rule Validation through Expert Engagement: To collaborate with pediatricians and child protection specialists in validating whether the extracted rules are clinically relevant, ethically sound, and aligned with best practices.

2. Retrospective Data Analysis: To apply the validated rules to the historical dataset and investigate two key questions: Were there cases that

should have been flagged as NAP according to the extracted rules but were not? Among the cases labeled as NAP, did they conform to the identified rules?

This dual approach—combining expert-validated knowledge extraction and retrospective rule-based analysis—aims to explore how AI can contribute meaningfully to safeguarding vulnerable patients while respecting the ethical boundaries of its application. Rather than viewing AI as a replacement for human decision-making, this study advocates for its use as a cognitive assistant that supports clinical reasoning, reduces the cognitive load associated with complex guidelines, and enhances accountability in child protection practices.

Chapter 2

Related Works

The application of Artificial Intelligence (AI) in the detection of child abuse and neglect is still in an early phase compared to its deployment in other medical domains. A systematic review by Lupariello et al. [10] identified only seven studies using AI techniques—such as artificial neural networks and natural language processing—to support child abuse detection. These studies drew on heterogeneous datasets, including imaging, clinical notes, and demographic data. However, all reviewed works presented methodological shortcomings, including small sample sizes (median of 2,600 cases), lack of external validation, and high risk of bias, thereby limiting their practical applicability. A more recent contribution by Landau et al. [9] emphasized the importance of incorporating socio-economic context into AI models. Their study showed that enriching models with the Area Deprivation Index significantly improved both sensitivity and fairness in the detection of child neglect. These findings point to the necessity of designing AI tools that are contextually aware and socially informed.

The deployment of AI in child protection must be approached with heightened ethical scrutiny due to the irreversible consequences of false positives or false negatives. A prominent example is the *Allegheny Family Screening Tool* used in Pittsburgh, USA, which came under investigation by the U.S. Department of Justice due to concerns about algorithmic discrimination, particularly

against families with disabilities. Critics argued that the algorithm's dependence on biased historical data could reinforce systemic inequalities, leading to unfair risk assessments of marginalized populations [11, 6]. In response to such concerns, the *AEQUITAS* project proposes a preemptive, ethically grounded methodology for assessing the appropriateness of AI systems prior to development [3]. AEQUITAS promotes a "fair-by-design" approach and introduces the *Trustworthy AI Readiness Assessment Framework* as a foundational step to identify ethical, legal, and societal constraints before model training. It emphasizes the use of representative datasets, fairness-aware algorithms, and transparent decision logic. In addition, AEQUITAS advocates for the structured involvement of multidisciplinary stakeholders—including legal experts, social scientists, clinicians, and technical AI developers—to ensure that AI systems are aligned with the values and constraints of their application context [2]. This methodology has served as the foundational framework for this thesis, informing the decision to refrain from predictive modeling on the available dataset due to its statistical and ethical limitations, and guiding the exploration of alternative AI applications.

Given the limitations of fully autonomous AI in ethically sensitive domains, recent studies have advocated for a more collaborative paradigm between human experts and AI systems. Kawakami et al. [8] examined the use of AI decision-support tools in child welfare settings and found that human oversight was essential to contextualize and interpret algorithmic outputs responsibly. Similarly, De-Arteaga et al. [4] highlighted the risk of overreliance on algorithmic scores and emphasized the need for systems that augment rather than replace professional judgment. In alignment with this perspective, our thesis explores the use of large language models (LLMs) not for classification but for knowledge extraction. Specifically, we investigate whether LLMs can assist in parsing dense clinical guidelines and extracting computable rules to support physician decision-making in real-time. This approach not only reduces the cognitive burden on clinicians but also ensures that AI remains a

transparent and accountable decision-support tool.

To evaluate the validity of the rules extracted via LLMs, we conducted a review of validated screening tools developed to assist physicians in emergency settings. Two of the most robust tools we identified—*ESCAPE* and *SCAN*—were both developed under the leadership of Dr. Patrycja Puiman in the Netherlands and align closely with our research objectives. The *ESCAPE* tool consists of six binary (yes/no) questions covering aspects such as the consistency of the injury with the child's history, delay in seeking care, the plausibility of the trauma based on developmental age, caregiver–child interactions, full body examination, and physician intuition. Its implementation led to a fivefold increase in abuse detection and raised screening rates from 20% to 67% in Dutch emergency departments [16, 13]. Building on this work, the *SCAN* (Screening instrument for Child Abuse and Neglect) tool refined the approach into a shorter, four-question checklist based on multivariate analysis of a large cohort of children across eight EDs. SCAN showed a pooled AUC of 0.75, demonstrating good discriminative ability [7]. The checklist includes questions on injury plausibility, delays in presentation, caregiver behavior, and clinician concern—precisely the kind of heuristics that AI might help standardize in support of early detection.

In this thesis, these validated instruments serve as essential benchmarks. We compare the screening questions extracted via LLMs from official guidelines to those embedded in ESCAPE and SCAN. This comparative validation aims to assess whether LLMs can successfully reproduce expert-validated reasoning and thus offer scalable, assistive tools. This validation effort contributes to the broader goal of ensuring that AI in child protection serves as a reliable and ethically responsible assistant to healthcare professionals, particularly in high-stakes environments such as pediatric emergency care.

In the following two sections of this chapter, we will take a closer look at ESCAPE and at SCAN, to better understand the idea behind their development, their characteristics, and their performance.

2.1 ESCAPE

Escape is a screening tool used in Emergency Departments in the Netherlands for the early detection of potential child abuse.

The tool was created to be accurate and quick so that it could be used massively, for patients in Emergency Departments.

It was developed by a multidisciplinary team and implemented in three Dutch hospitals. The six-item checklist was completed for every minor that entered the ED by a nurse during triage. The use of the instrument didn't depend on the reason for which the minor was at the hospital, this way the team gathered a large set of data in relatively a short amount of time. If at least one item of the checklist was considered positive by the nurse, then the screening result would be considered positive and the ED physician would be alerted.

The checklists were completed for 18,275 ED visits, the data was used to calculate the overall specificity, sensitivity and the positive/negative predictive values of the cases. The data and clinical notes of potentially abused children were given to the hospitals' Child Abuse Teams and reviewed - case by case - by an expert panel.

Using a logistic regression model, the predictors of potential abuse were evaluated.

The study resulted in the identification of 44 potential abuse cases for the 420 cases flagged as positive by the instrument, and 11 of the 17,855 cases not flagged by the checklist were deemed as potential cases of abuse by the experts.

The specificity of ESCAPE is 0.98 and the sensitivity is 0.80. This instrument is a useful support in the ED for early detection of potential abuse in children.

2.1.1 The questions

ESCAPE is a checklist made up of six questions that address risk factors for child abuse.
One or more positive answers determine an increase risk of child abuse.
Here are the six questions:

1. Is the history consistent?
2. Was seeking medical help unnecessarily delayed?
3. Does the onset of the injury fit with the developmental level of the child?
4. Is the behavior of the child, the carers, and their interaction appropriate?
5. Are findings of the head-to-toe examination in accordance with the history?
6. Are there other signals that make you doubt the safety of the child or other family members?

2.2 SCAN

This study was conducted with the aim of developing a validated Screening instrument for the recognition of Child Abuse and Neglect (SCAN). For this study, data was gathered from three large screening studies in 8 EDs in Netherlands. The team applied a logic multivariate regression model to the data in order to identify predictive questions. The tool was then validated using cross-validation.

In this study the data involved 24,963 children.

The final questionnaire was made up of 4 questions, and the validation confirmed consistency throughout the different datasets.

SCAN can be seen as a sort of 'evolution' of ESCAPE, as it is built from ESCAPE's results, but it is a fully validated, standardized, and easier to use, since it has fewer questions.

The instrument performs with an Area Under the Curve (AUC) of 0.75, which indicates a good discriminative capability.

2.2.1 The questions

Each question was associated with a predictive value, expressed as an Adjusted Odds Ratio (aOR), which indicates how strongly the presence of that indicator is associated with a confirmed case of abuse after adjusting for potential confounding factors. Here are the four questions that make up SCAN:

1. Is the injury compatible with the history, and does it correspond to the child's developmental level? (Adjusted Odds Ratio (aOR): 10.40)

2. Was there an unnecessary delay in seeking medical help? (Note: This refers specifically to the caregiver's delay, not the medical system's.) (aOR: 3.45)

3. Is the behaviour/interaction of the child and parent(s) appropriate? (aOR: 14.67)

4. Are there other signals that make you doubt the safety of the child and/or family? (OR: 182.9 (added by expert consensus))

Chapter 3

Data Sources

Sant'Orsola Hospital has provided us with their patients' dataset.

Additionally, the doctors shared with us a compilation of professional medical manuals detailing what to look for in children admitted to the E.R. in order to identify cases of suspected abuse.

3.1 The Dataset

The Dataset is composed of 12 tables that describe the medical data of approximately 20000 patients.

The tables are:

- Admissions
- Personal Information
- Admissions-Discharges
- Short Intensive Observation (OBI)
- Main Problem
- Orders
- Symptoms

- Clinical Data
- Hospitalization
- Triage
- Procedures
- Procedure Dictionary

The most relevant data for our project is located in the **'Clinical Data'** and the **'Admissions-Discharges'** tables. Together, these two tables combine the explanation provided by the caregivers or the child, the context of the injury, the description of the injury or injuries of the child, the following of the injury (prescription of exams, reports of the results of the exams, etc..), and the discharge explanation, that is, the therapy or medication prescribed, or, in cases of suspected abuse, the steps that will follow, including the explanation that the social services were called, or the explanation that the caregiver will go to the police, etc...

These records are circa 60000.

The clinical data reported for each of the patients it is unstructured. It is a text that is made up of a mixture of descriptions, exam procedures, exam results, patient's explanations, unconfirmed and confirmed injury reports.

The fact that the data is unstructured - and not a clear list of symptoms - along with the fact that the dataset is heavily unbalanced - which is good because it means that there aren't a lot of cases of child abuse, but it is bad for building an accurate classification model- resulted in the fact that we decided to discard the idea of developing a classification model that took into input a list of symptoms and determined the probability of potential child abuse.

In turn, this decision pushed us to lean towards a solution more similar to the ESCAPE and SCAN instruments, that is to base our studies on the manuals provided by Sant'Orsola's doctors, and create a checklist that will be a

supporting tool for the Italian ED doctors to identify cases of potential abuse in children.

3.2 The Manuals

The following collection of manuals on the symptoms of child abuse served as the primary source for this thesis.

1. **Linee di indirizzo regionali per l'accoglienza e la cura di bambini e adolescenti vittime di maltrattamento/abuso' - Bambini e adolescenti - Regione Emilia Romagna**
2. **Maltrattamento e abuso sul minore. Raccomandazioni per la valutazione clinica e medico-legale**
3. **Fratture e abuso. Raccomandazioni per il percorso diagnostico - Maltrattamento e abuso sul minore**
4. **Valutazione e recuperabilità del danno evolutivo e delle competenze genitoriali nel maltrattamento dell'infanzia e adolescenza - Maltrattamento e abuso sul minore**
5. **Lesioni cutanee, mucose e degli annessi cutanei da maltrattamento/abuso su persone di minore età - Maltrattamento e abuso sul minore**
6. **Lesioni viscerali da maltrattamento/abuso nelle persone di minore età - Maltrattamento e abuso sul minore**
7. **Violenza di genere. Raccomandazioni per la valutazione clinica e medico-legale - Maltrattamento e abuso sul minore**

These manuals outline all the steps doctors must follow from the moment a patient enters the hospital. They cover how to communicate with the patient, what signs to look out for, which examinations to perform, the diagnostic process, and how to plan the next steps. To extract the underlying rules from

these manuals, we used AI techniques based on LLMs. The methodology and results of this process are detailed in the following chapter.

Chapter 4

Rules Extraction via GenAI

We have decided to try AI techniques in order to extract the rules contained in each of the manuals, the aim, the method and the results of these extractions will be detailed in this chapter.

While the problem of trying to identify cases of suspected child abuse at the earliest stages is a problem that we, as Italians, share with the world, it does not mean that the same methods, and the same rules apply in an equally successful manner in all parts of the world: what may work in the USA for example, may not work in Italy. The symptoms may not present themselves in the same way, the behavior of the child may differ for cultural reasons, etc. Therefore, we must base our solution on the manuals we were given, since they are specifically tailored for our location and our culture.

4.1 Method and Prompt Engineering

The first thing to do, is choose the best LLM to perform the rule extraction task. For this purpose we took into consideration various models and researched the available academic literature to observe the evaluation of different models while performing information extraction tasks, in terms of quality of the results, but also efficiency, with a focus on its performance in tasks regarding

unstructured data and semistructured data. Ideally the data would be clinical data as well. We found that Openai's gpt-4 model has an outstanding performance in terms of efficacy with an accuracy equal to 0.988, similarly to the Claude LLMs. We learned these accuracy values from the recent study by Ntinopoulos et al. (2025), which evaluated multiple large language models on the task of extracting information from unstructured and semi-structured Electronic Health Records (EHRs) [12]. We chose gpt over Claude, because it is more efficient, in particular we used Openai's gpt-4.1 model.

In our code, the first thing we did was extracting the texts from the manuals and then we passed the extracted texts as input to the gpt model. We took the resulting rules and wrote them in an output document for each manual. We did this so that we could perform many tests changing the prompts and the temperature, so that we could compare the results and select the variable combination that better fit our needs.

The final prompt we specified is: *"Estrai le regole principali per determinare se un bambino ha subito abusi dal seguente testo clinico:*testo-estratto-dal-pdf*. Scrivi le regole in forma strutturata e concisa in italiano."* (English translation: *"Extract the main rules for determining whether a child has been abused from the following clinical text: text-extracted-from-pdf. Write the rules in a structured and concise form in Italian."*). This prompt yielded the best results, together with the chat-system role specification: *"Sei un esperto di medicina legale pediatrica."*, which translates to *"You are an expert in pediatric forensic medicine."*; and a temperature of 0.3.

Before reaching this successful combination, we performed many tests changing the values of these variables.

We tested the effects of the temperatures changing its value to values ranging from 0.1 to 0.9 [0.1, 0.3, 0.5, 0.9]. The results were initially very similar, so we kept repeating the experiments and, through repetition, we found the best result in 0.3, which will be reported in the Results section (4.2). Using the other temperatures, we didn't reach a result as good as the one reached

with 0.3, but for each of the other values we found fairly consistent results. Surprisingly, there were not dramatic drops in performance even while using the highest values.

We also tried two different main prompts:

1. ”Estrai le regole per la classificazione di abusi” (”Extract the rules for abuse classification”)

2. ”Estrai le regole principali per determinare se un bambino ha subito abusi” (”Extract the main rules to determine whether a child has been abused”)

Using the same temperature and the same role, the model using the two different prompts in some tries returned very similar results, but in other tries, including the best try, it returned drastically better results with the second prompt. An example of the rules extracted while using the first prompt and the rules extracted using the second prompt is shown in table 4.1.

We first tested with the role *'doctor'* and then changed it to the more specific: *”You are an expert in pediatric forensic medicine.”*. We found that a clearer role definition, yielded slightly more detailed and focused rules. For example, in the first document, only with the second prompt do the rules extracted include the child's behavioral signs of abuse (behavioral or emotional changes). That is why we favored the second prompt.

We also first experimented without the addition of this part of the prompt: *'Write the rules in a structured and concise form'*. Without the structure-specifying part of the prompt, we found that the result was indeed still structured, but less detailed, as shown in figure 4.1, compared to the structured form of the rule extracted from the same document- *'Linee di indirizzo regionali per l'accoglienza e la cura di bambini e adolescenti vittime di maltrattamento/abuso - Bambini e adolescenti - Regione Emilia Romagna'* - using the same temperature (figure 4.2).

Extract the rules for abuse classification	**Extract the main rules to determine whether a child has been abused**
In cases of suspected maltreatment or abuse, a series of intervention steps must be initiated: Detection, activation of the service network, reporting to judicial authorities and protective measures, multidisciplinary assessment, and treatment.	Classification of forms of abuse: Abuse can be physical, psychological, sexual, or take the form of witnessed violence, online abuse, neglect and inadequate care, or peer violence such as bullying.
Forms of abuse or maltreatment can be classified as physical abuse, psychological abuse, witnessed violence, sexual abuse, sexual exploitation, online abuse, neglect and inadequate care, and peer violence such as bullying and cyberbullying.	1. Physical abuse: Presence of non-accidental physical injuries (bruises, fractures, burns, bites, etc.); Inconsistency between the explanation provided and the injuries observed; Injuries with different stages of healing or in atypical locations. 2. Psychological abuse: Behaviors that harm the child's self-esteem, sense of safety, or emotional well-being (humiliation, threats, isolation, rejection, psychological terror); Signs of emotional or behavioral disorders without apparent cause. 3. Witnessed violence: Exposure of the child to domestic violence between caregivers (even if not directly involved). 4. Sexual abuse: Involvement of the child in sexual activities that are inappropriate for their age or development; Physical signs (genital injuries, sexually transmitted infections) or behavioral signs (regression, early sexualized behaviors). 5. Online abuse: Exposure to sexually explicit material, grooming, threats, or blackmail via the internet. 6. Pathological caregiving: Physical or emotional neglect (lack of medical care, hygiene, nutrition, affection); Harmful overprotection or excessive caregiving. 7. Peer violence: (bullying/cyberbullying) Repeated acts of domination, exclusion, threats, or aggression among peers, including via digital means.

Table 4.1: Table of examples of extracted rules, using the first and second prompt, in different tries.

2. Classificazione delle forme di maltrattamento e abuso: Il maltrattamento può essere fisico, psicologico, sessuale o può avvenire online. Il maltrattamento fisico include qualsiasi azione che causa danno fisico a un bambino, mentre il maltrattamento psicologico può includere comportamenti come l'umiliazione, l'intimidazione o la negligenza. L'abuso sessuale include qualsiasi comportamento sessuale inappropriato nei confronti di un bambino.

Figure 4.1: Rule extracted without the structuring prompt.

1.1. Maltrattamento fisico
- Presenza di lesioni fisiche non accidentali (lividi, fratture, ustioni, morsi, ecc.).
- Incoerenza tra spiegazione fornita e lesioni riscontrate.
- Lesioni di diversa datazione o localizzazione atipica.

1.2. Maltrattamento psicologico
- Comportamenti che ledono l'autostima, la sicurezza o il benessere emotivo del bambino (umiliazioni, minacce, isolamento, rifiuto, terrore psicologico).
- Segni di disturbi emotivi o comportamentali senza cause apparenti.

1.3. Violenza assistita
- Esposizione del bambino a violenza domestica tra adulti di riferimento (anche se non direttamente coinvolto).

1.4. Abuso sessuale
- Coinvolgimento del minore in attività sessuali non adeguate all'età o allo sviluppo.
- Segni fisici (lesioni genitali, infezioni sessualmente trasmesse) o comportamentali (regressione, sessualizzazione precoce).

Figure 4.2: Rule extracted with the addition of the structuring prompt.

Since llms are not deterministic, we performed many rule extractions, and kept the best results.

The code can be found on github at the following link: AEQUITAS - Child Abuse and Neglect.

4.2 Results

In this section, we will compile the list of rules that were drawn from each manual.

4.2.1 Linee di indirizzo regionali per l'accoglienza e la cura di bambini e adolescenti vittime di maltrattamento/abuso - Bambini e adolescenti - Regione Emilia Romagna

The title of the manual roughly translates to *Regional Guidelines for the reception and care of children and adolescents victims of maltreatment/abuse - Emilia-Romagna Region*.

Here are the extracted rules:

- **Physical Abuse**
  - Presence of non-accidental physical injuries (bruises, fractures, burns, bites, etc.).
  - Inconsistency between the explanation provided and the injuries observed.
  - Injuries of different ages or in unusual locations.
- **Psychological Abuse**
  - Signs of emotional or behavioral disorders with no apparent cause.
- **Sexual Abuse**
  - Physical signs (genital injuries, sexually transmitted infections) or behavioral indicators (regression, early sexualization).
- **Pathological Care**
  - Physical or emotional neglect (lack of medical care, hygiene, nutrition, affection).
  - Harmful overprotection or excessive care.
- **Symptoms**
  - Unexplained or recurring physical injuries.

- Sudden behavioral or emotional disturbances.
- Changes in school performance or social interactions.
- Fear or avoidance of certain people or places.
- Direct or indirect accounts of violence or abuse.

4.2.2 Maltrattamento e abuso sul minore. Raccomandazioni per la valutazione clinica e medico-legale

This manual is titled *Child Maltreatment and Abuse: Recommendations for Clinical and Forensic Evaluation* in english.

Here are the extracted rules:

- Unexplained or recurring injuries: presence of injuries with different dates of origin, atypical locations, or inconsistent or vague explanations.
- Delayed medical care seeking: delayed access to healthcare relative to the severity of the injury.
- Abnormal behavior in the child: unmotivated fear, hypervigilant attitude, avoidance of certain people or places, early sexualized behavior.
- Abnormal behavior in caregivers: hostile, excessively anxious or uncooperative attitude; frequent changes of doctor or healthcare facility.

4.2.3 Fratture e abuso. Raccomandazioni per il percorso diagnostico - Maltrattamento e abuso sul minore

This manual is titled *Fractures and Abuse: Recommendations for the Diagnostic Pathway – Child Maltreatment and Abuse* in english.

Here are the extracted rules:

- **Consistency between clinical history and injuries**

  - The reported dynamics are not consistent with the type, location, or number of fractures observed.
  - Absence of explanation or vague, contradictory, or implausible explanation for the injuries.

- **Type and location of fractures**
  - Fractures in locations typically associated with abuse (e.g., posterior ribs, metaphyses, scapula, sternum, vertebrae).
  - Multiple fractures of different ages or in various stages of healing.
  - Fractures in non-ambulatory children (e.g., infants).

- **Presence of other associated injuries**
  - Skin injuries (bruises, burns, bite marks, ligature marks).
  - Internal injuries (hemorrhages, visceral injuries) not explained by the provided history.

- **Delay in seeking medical care**
  - Unjustified delay between the alleged trauma and the request for medical assistance.

- **Recurrence of trauma**
  - Previous emergency visits for trauma or suspicious injuries, even if minor.

- **Behavior of the child and/or caregivers**
  - Abnormal, frightened, or excessively quiet behavior in the child.
  - Defensive, hostile, or uncooperative behavior from parents/caregivers.

- **At-risk social and family context**
  - Presence of social/family risk factors (isolation, social distress, prior reports of abuse/maltreatment).

4.2.4 Valutazione e recuperabilità del danno evolutivo e delle competenze genitoriali nel maltrattamento dell'infanzia e adolescenza - Maltrattamento e abuso sul minore

This manual's title would be *Assessment and Recoverability of Developmental Damage and Parental Competence in Cases of Child and Adolescent Maltreatment – Child Maltreatment and Abuse* in english.

Here are the extracted rules:

- **Careful and Systematic Assessment**
  - Conduct a thorough clinical and medico-legal evaluation, avoiding both underestimation and overestimation of developmental damage.
  - Do not infer the presence of trauma without solid diagnostic exploration.
- **Use of Evidence-Based Practices**
  - Apply scientifically validated tools and protocols for the diagnosis of maltreatment and abuse.
- **Multiprofessional and Multidisciplinary Approach**
  - Involve various professional figures (physicians, psychologists, social workers, educators) in the case assessment.
- **Assessment of Parental Competence**
  - Evaluate the parents' ability to ensure the child's safety and well-being.
- **Accurate Documentation**
  - Draft detailed and objective reports, also useful for judicial authorities.

- **Consideration of Organizational and Legal Context**
  - Take into account the guidelines and provisions of judicial authorities and the organization of territorial services.
- **Overcoming Common Obstacles**
  - Be aware of the main obstacles in the evaluation process (e.g., poor diagnostic aptitude, lack of tools, service organization) and adopt strategies to overcome them.

4.2.5 Lesioni cutanee, mucose e degli annessi cutanei da maltrattamento/abuso su persone di minore età - Maltrattamento e abuso sul minore

This manual is titled *Skin, Mucosal, and Appendage Injuries from Maltreatment/Abuse in Minors – Child Maltreatment and Abuse* in english.

Here are the extracted rules:

- **Injury Assessment**
  - Type of injury: Identify the nature (bruises, abrasions, burns, bites, injuries from blunt or sharp objects, etc.).
  - Location of injury: Injuries in atypical areas (chest, abdomen, back, buttocks, inner thighs, ears, neck, mucous membranes) are more suspicious.
  - Number and distribution: Multiple injuries, symmetric injuries, or injuries of different ages increase the suspicion of abuse.
  - Appearance and shape: Injuries with recognizable shapes (e.g., imprint of objects, belts, hands, teeth) are suggestive of non-accidental cause.
- **Consistency between injury and reported dynamics**

  - Incongruence: Discrepancy between the caregivers' report and the clinical characteristics of the injury.
  - Lack of explanation: Injuries with no plausible explanation or with vague, changing explanations, or those incompatible with the child's motor development.

- **Child's age and development**
  - Non-ambulatory age: Injuries in children who are not yet walking are particularly suspicious.
  - Compatibility with motor skills: Verify whether the injury is compatible with the child's developmental level.

- **Presence of associated signs**
  - Other signs of maltreatment: Signs of neglect, malnutrition, poor hygiene, growth delay, or behavioral changes.
  - Injuries of different ages: Presence of injuries in various stages of healing.

- **Medical history and anamnesis**
  - Previous episodes: History of repeated emergency visits or medical consultations for trauma or injuries.
  - Previous reports: Any previous reports of suspected abuse or maltreatment.

- **Differential diagnosis**
  - Rule out medical causes: Evaluate for conditions that may mimic abuse-related injuries (bleeding disorders, skin diseases, bone fragility, etc.).

  - Multidisciplinary consultation: Involvement of specialists (pediatrician, dermatologist, forensic physician, psychologist) for an integrated assessment.

4.2.6 Lesioni viscerali da maltrattamento/abuso nelle persone di minore età - Maltrattamento e abuso sul minore

This manual's title translation is *Visceral Injuries from Maltreatment/Abuse in Minors – Child Maltreatment and Abuse*.

Here are the extracted rules:

- **Anamnesis and Trauma Dynamics**
  - Injuries that are unexplained or whose explanations are inconsistent with the child's age and developmental stage.
  - Absent, vague, contradictory, or clinically incompatible medical history.
  - Delay in seeking medical care without a plausible explanation.
- **Characteristics of Injuries**
  - Presence of visceral injuries (abdominal, thoracic, cranial) without clear accidental trauma.
  - Multiple injuries or injuries at different stages of healing.
  - Injuries associated with signs of old wounds, fractures, or scars.
  - Injuries located in areas atypical for accidental trauma (e.g., chest, abdomen, back, buttocks, inner thighs).
- **Physical Examination**
  - Presence of other signs of abuse: bruises, burns, bite marks, cutaneous or mucosal injuries.

  - Evidence of neglect or malnutrition.

- **Differential Diagnosis**

  - Exclusion of medical conditions that may mimic abuse-related injuries (bleeding disorders, osteogenesis imperfecta, etc.).
  - Evaluation of potential accidental causes consistent with the injuries.

- **Multidisciplinary Approach**

  - Involvement of specialists (pediatrician, radiologist, forensic physician, social worker, psychologist).
  - Detailed reporting and photographic documentation of injuries.

- **Mandatory Reporting**

  - In cases of well-founded suspicion of abuse, there is a legal obligation to report to the competent authorities (Public Prosecutor's Office at the Juvenile Court).

4.2.7 Violenza di genere. Raccomandazioni per la valutazione clinica e medico-legale - Maltrattamento e abuso sul minore

This manual's title's translation would be *Gender-Based Violence: Recommendations for Clinical and Forensic Evaluation – Child Maltreatment and Abuse*.

Here are the extracted rules:

- **Anamnesis Collection**

  - Attentive and nonjudgmental listening to the child and caregivers.

  - Consistency and coherence between the reported history and observed injuries.
  - Presence of delays in seeking care or vague/inconsistent explanations.

- **Physical Examination**
  - Complete assessment of the body: check for injuries at various stages of healing.
  - Typical injuries: bruises, fractures, burns, bite marks, ligature marks, genital/anal injuries.
  - Injury distribution: special attention to atypical areas (chest, back, buttocks, back of the legs).

- **Assessment of Injury-History Compatibility**
  - Inconsistencies between the reported mechanism and the characteristics of the injuries.
  - Injuries incompatible with the child's motor development (e.g., fractures in non-ambulatory infants).

- **Signs of Neglect**
  - Poor hygiene, inappropriate clothing, malnutrition.
  - Failure to provide necessary medical care.

- **Behavioral Indicators**
  - Sudden behavioral changes (regression, withdrawal, aggression).
  - Unexplained fear towards adults or specific individuals.

- **Documentation**
  - Detailed recording of all injuries, including description, measurements, and photographic documentation if possible.

  - Preservation of potential evidence (clothing, swabs, etc.).

- **Multidisciplinary Evaluation**

  - Involvement of specialized teams (pediatrician, forensic doctor, psychologist, social worker).
  - Mandatory reporting to social services and judicial authorities in cases of well-founded suspicion.

4.3 Observations on the results

Some of the manuals focus on a list of behaviors the medic should have, or on the legal proceedings that should unfold from the recognition of a case of suspected child abuse. These rules are out of the scope of this thesis. Therefore, we will discard those extracted rules and instead focus on the rules that explain the symptoms that an abused child could present, and on what the doctor should focus on in order to detect the abuse and to raise the suspicion of the abuse.

Many of the themes and symptoms are recurrent throughout the manuals, so we will now gather the useful rules and order them in a more structured way, grouping them by theme.

We will proceed in the following way: we will start with the rules extracted from the manual that yielded the shortest list of rules, which is the second manual, *Maltrattamento e abuso sul minore. Raccomandazioni per la valutazione clinica e medico-legale (Child Maltreatment and Abuse: Recommendations for Clinical and Forensic Evaluation)*. These four rules are structured like so: ”Category: Description”. For example, the rule *”Unexplained or recurring injuries: presence of injuries with different dates of origin, atypical locations, or inconsistent or vague explanations”* is made up of two parts, divided by the two points ’:’. This applyes for each of the 4 rules extracted from this manual,

as shown in the following example:
RULE 1:

1. **Category:** Unexplained or recurring injuries.
2. **Description:** presence of injuries with different dates of origin, atypical locations, or inconsistent or vague explanations.

RULE 2:

1. **Category:** Delayed medical care seeking.
2. **Description:** delayed access to healthcare relative to the severity of the injury.

RULE 3:

1. **Category:** Abnormal behavior in the child.
2. **Description:** unmotivated fear, hypervigilant attitude, avoidance of certain people or places, early sexualized behavior.

RULE 4:

1. **Category:** Abnormal behavior in caregivers.
2. **Description:** hostile, excessively anxious or uncooperative attitude; frequent changes of doctor or healthcare facility.

We can see that these are rules that deal with different themes, there is no content overlap in the descriptions.

We will use these four categories as the theme-groups that we'll proceed to group all of the rules into.

To proceed, we'll iterate through the manuals, and for each rule we encounter, we'll identify in which group it belongs to, judging by its content, and copy it there.

If we encounter a rule that doesn't fit into one of the four categories, then we create a new category.

For example, we'll start from the first rule in the first manual, that is the manual titled *Linee di indirizzo regionali per l'accoglienza e la cura di bambini e adolescenti vittime di maltrattamento/abuso - Bambini e adolescenti - Regione Emilia Romagna (Regional Guidelines for the reception and care of children and adolescents victims of maltreatment/abuse - Emilia-Romagna Region)*. The first rule is:

Physical Abuse

- Presence of non-accidental physical injuries (bruises, fractures, burns, bites, etc.).
- Inconsistency between the explanation provided and the injuries observed.
- Injuries of different ages or in unusual locations.

We see that this is a rule that is made up of 3 rules inside of a grouping. We will consider each of these 3 'inner' rules singularly.

We take the first inner rule: *Presence of non-accidental physical injuries (bruises, fractures, burns, bites, etc.)*. Although the rule we are considering also deals with physical injuries, it doesn't fit into the group that we called **'Unexplained or recurring injuries'**. We can't put it in the mentioned category because this rule describes types of physical injuries that are consistent with abuse, but it doesn't mention that they are recurring nor unexplained.

The groups we defined are not enough to fit this rule, so we'll create a new group called **Nature of the injury**, to encompass all of the rules that define the physical symptoms that the doctors should look out for. This group will deal with lists of types of physical injuries, their description, their location, etc...

We will write the rule *"Presence of non-accidental physical injuries (bruises, fractures, burns, bites, etc.)"* in the rule-group **Nature of the injury**.

Now we'll consider the second rule: *Inconsistency between the explanation provided and the injuries observed.*.

This rule deals with injuries, like the previous rule, but it also deals with explanations. It deals with the relationship between the explanation given for the injury and the actual injury. It is closely related to the group **'Unexplained or recurring injuries'**, especially with the clause 'Unexplained', but the rule we are considering doesn't say that the injury is 'unexplained', but rather that it is explained, but the explanation is inconsistent. We recall that in the original definition of the rule from manual two, from which we took the name of the category, the given description included *'[...] or inconsistent or vague explanations'*. Which is closely semantically related with the rule we are considering, as it deals with 'inconsistent [...] explanations', therefore these two rules should be grouped together. Still, we saw that the name of this category is not appropriate, so we will change it to **'Inconsistent or recurring injuries'**.

This category now looks like this (we will order the rules following the order of the manuals): **Inconsistent or recurring injuries**:

- Inconsistency between the explanation provided and the injuries observed. (from manual one)
- Presence of injuries with different dates of origin, atypical locations, or inconsistent or vague explanations. (from manual two)

Now we will consider the third rule: *Injuries of different ages or in unusual locations.*

This rule fits both into the **Inconsistent or recurring injuries** - because it mentions *'injuries of different ages [...]'* and that sentence implies the presence of multiple injuries that occurred at different times (repetition) - and in the category **Nature of the injury**, because the rule describes the location of the injury (*Injuries [...] in unusual locations*). Therefore, we will add this rule into both groups.

Nature of the injury:

- Presence of non-accidental physical injuries (bruises, fractures, burns, bites, etc.).
- Injuries of different ages or in unusual locations.

Inconsistent or recurring injuries:

- Inconsistency between the explanation provided and the injuries observed. (from manual one)
- Injuries of different ages or in unusual locations. (from manual one)
- Presence of injuries with different dates of origin, atypical locations, or inconsistent or vague explanations. (from manual two)

We will follow this process for each rule extracted from all the manuals.

Note that while iterating through the rules extracted from all the manuals, we will also consider the description-part of the rules given in the second manual, because, although we started from that manual to define the categories, the categories have already been changed or expanded to accommodate and fully encompass all the rules from the other manuals. That means that there are rules from the second manual that may end up belonging to different new categories, for example the rule *Presence of injuries with different dates of origin, atypical locations, or inconsistent or vague explanations.* Belongs in the category **'Unexplained or recurring injuries'** but also in the category **Nature of the injury**, because it adds specifications on the location of the injury ('atypical location').

Here is the new ordering of the extracted rules:

- **Nature of the injury**:
  - Presence of non-accidental physical injuries (bruises, fractures, burns, bites, etc.).

- injuries of different ages or in unusual locations.
- Physical signs of sexual abuse (genital injuries, sexually transmitted infections)
- Fractures in locations typically associated with abuse (e.g., posterior ribs, metaphyses, scapula, sternum, vertebrae).
- Fractures in non-ambulatory children (e.g., infants).
- Skin injuries (bruises, burns, bite marks, ligature marks).
- Internal injuries (hemorrhages, visceral injuries) not explained by the provided history.
- bruises, abrasions, burns, bites, injuries from blunt or sharp objects, etc.
- Injuries in atypical areas (chest, abdomen, back, buttocks, inner thighs, ears, neck, mucous membranes).
- Multiple injuries, symmetric injuries, or injuries of different ages.
- Injuries with recognizable shapes (e.g., imprint of objects, belts, hands, teeth)
- Presence of visceral injuries (abdominal, thoracic, cranial) without clear accidental trauma.
- Multiple injuries or injuries at different stages of healing.
- Injuries associated with signs of old wounds, fractures, or scars.
- Injuries located in areas atypical for accidental trauma (e.g., chest, abdomen, back, buttocks, inner thighs).
- Presence of other signs of abuse: bruises, burns, bite marks, cutaneous or mucosal injuries.
- Evidence of neglect or malnutrition.
- Check for injuries at various stages of healing.

  - Bruises, fractures, burns, bite marks, ligature marks, genital/anal injuries.
  - special attention to atypical areas (chest, back, buttocks, back of the legs).

- **Inconsistent or recurring injuries**:
  - Inconsistency between the explanation provided and the injuries observed.
  - Injuries of different ages or in unusual locations.
  - Presence of injuries with different dates of origin, atypical locations, or inconsistent or vague explanations.
  - The reported dynamics are not consistent with the type, location, or number of fractures observed.
  - Absence of explanation or vague, contradictory, or implausible explanation for the injuries.
  - Multiple fractures of different ages or in various stages of healing.
  - Fractures in non-ambulatory children (e.g., infants).
  - Internal injuries (hemorrhages, visceral injuries) not explained by the provided history.
  - Previous emergency visits for trauma or suspicious injuries, even if minor.
  - Multiple injuries, symmetric injuries, or injuries of different ages.
  - Discrepancy between the caregivers' report and the clinical characteristics of the injury.
  - Injuries with no plausible explanation or with vague, changing explanations, or those incompatible with the child's motor development.
  - Injuries in children who are not yet walking.

  - Injury incompatible with the child's developmental level.
  - Presence of injuries in various stages of healing.
  - Injuries that are unexplained or whose explanations are inconsistent with the child's age and developmental stage.
  - Consistency and coherence between the reported history and observed injuries.
  - Presence of delays in seeking care or vague/inconsistent explanations.
  - Check for injuries at various stages of healing.
  - Inconsistencies between the reported mechanism and the characteristics of the injuries.
  - Injuries incompatible with the child's motor development (e.g., fractures in non-ambulatory infants).

- **Delayed medical care seeking**:
  - Delayed access to healthcare relative to the severity of the injury.
  - Unjustified delay between the alleged trauma and the request for medical assistance.
  - Delay in seeking medical care without a plausible explanation.
  - Presence of delays in seeking care or vague/inconsistent explanations.

- **Signs of neglect**:
  - Signs of neglect, malnutrition, poor hygiene, growth delay, or behavioral changes.
  - Poor hygiene, inappropriate clothing, malnutrition.
  - Failure to provide necessary medical care.

- **Inconsistent medical history**:
  - History of repeated emergency visits or medical consultations for trauma or injuries.
  - Previous reports of suspected abuse or maltreatment.
  - Absent, vague, contradictory, or clinically incompatible medical history.
- **Abnormal behavior in the child:**:
  - Signs of emotional or behavioral disorders with no apparent cause.
  - Behavioral indicators of sexual abuse (regression, early sexualization).
  - Sudden behavioral or emotional disturbances.
  - Fear or avoidance of certain people or places.
  - Direct or indirect accounts of violence or abuse.
  - Unmotivated fear, hypervigilant attitude, avoidance of certain people or places, early sexualized behavior.
  - Abnormal, frightened, or excessively quiet behavior in the child.
  - Sudden behavioral changes (regression, withdrawal, aggression).
  - Unexplained fear towards adults or specific individuals.
- **Abnormal behavior in caregivers:**:
  - Physical or emotional neglect (lack of affection).
  - Harmful overprotection or excessive care.
  - Direct or indirect accounts of violence or abuse.
  - hostile, excessively anxious, or uncooperative attitude; frequent changes in the doctor or healthcare facility.
  - Defensive, hostile, or uncooperative behavior from parents/caregivers.

4.3.1 Analysis of the rules

There are two problems with the groups created:

1. There are some duplicated rules within the same group, or cases in which the same rule is worded differently, where the meaning of two rules is overlapping.

2. Some of the groups overlap, for example, the rule *'Check for injuries at various stages of healing'* fits both in the **'Nature of the injury'** group and the **'Inconsistent or recurring injuries'** group.

We want to organize the rules extracted into clean groups, with clear rules. We want to eliminate any overlapping both on a syntax level, and on a content level.

In this section we will remove duplicates within the same group and merge overlapping groups, for example, we can merge **'Nature of the injury'** and **'Inconsistent or recurring injuries'** into a group called **'Characteristics, consistency, and recurrence of the injuries'**. We will also merge the groups **'Abnormal behavior in the child'** and **'Abnormal behavior in caregivers'** which both include the rule *'Direct or indirect accounts of violence or abuse.'*, into a group called: **Abnormal behavior in the child or in the caregivers**.

Duplicates to be removed or merged are for example: *"Unjustified delay between the alleged trauma and the request for medical assistance"*, *"Delay in seeking medical care without a plausible explanation"*,*"Presence of delays in seeking care or vague/inconsistent explanations."*, that we can merge into a single rule that includes all three of them, such as *"Unjustified delay between the alleged trauma and the request for medical assistance, without a plausible explanation or with vague/inconsistent explanations"*.

4.3.2 The merging process

To perform this merge we will consider one group at a time. From the considered group we will analyze rule by rule and for each rule, we will first locate the rules that are 'duplicates' of this rule we are currently considering either in syntax or in meaning, and from that group of rules we will choose the most generic rule, that is, the rule that best encompasses the meanings of the other rules in itself. We keep that selected rule and eliminate the rest of the duplicates.

Here is an example of the process.

We take the first rule of the first category, that is rule *Presence of non-accidental physical injuries (bruises, fractures, burns, bites, etc.)* from category **Nature of the injury**.

We read through the list of rules belonging to the same category and see if this rule overlaps with any of them.

- Injuries of different ages or in unusual locations: **NO OVERLAP**.
- Physical signs of sexual abuse (genital injuries, sexually transmitted infections) : **NO OVERLAP**.
- Fractures in locations typically associated with abuse (e.g., poste-rior ribs, metaphyses, scapula, sternum, vertebrae). : **small OVERLAP**. It shares 'fractures' with the rule we are considering, but the overlap is not big enough to make one rule that covers the symptoms covered by both the rules. It would create a very long rule with nested parentheses (Presence of non-accidental physical injuries (bruises, fractures in locations typically associated with abuse (e.g., poste-rior ribs, metaphyses, scapula, sternum, vertebrae), burns, bites, etc.)) so we decide to keep both of the rules separate.
- Fractures in non-ambulatory children (e.g., infants): **see the rule above**.

- Skin injuries (bruises, burns, bite marks, ligature marks) : **OVERLAP**. The overlap encompasses almost completely this rule. It includes bruises, burns and bites. We encompass the whole rule in the rule we are considering by adding 'ligature marks' in the parentheses ⇒ **'Presence of non-accidental physical injuries (bruises, fractures, burns, bites, ligature marks etc.)'**. With the updated rule, we can delete this rule from the group.

- Internal injuries (hemorrhages, visceral injuries) not explained by the provided history: **NO OVERLAP**.

- bruises, abrasions, burns, bites, injuries from blunt or sharp objects, etc.: **OVERLAP** of the words bruises, burns, bites. Let's add the words that are currently not included to the list defined in the currently considered rule ⇒ **'Presence of non-accidental physical injuries (bruises, fractures, burns, bites, ligature marks, abrasions, injuries from blunt or sharp objects, etc.)'**. With the updated rule, we can delete this rule from the group.

- Injuries in atypical areas (chest, abdomen, back, buttocks, inner thighs, ears, neck, mucous membranes): **NO OVERLAP**.

- Multiple injuries, symmetric injuries, or injuries of different ages.: **NO OVERLAP**.

- Injuries with recognizable shapes (e.g., imprint of objects, belts, hands, teeth): **NO OVERLAP**.

- Presence of visceral injuries (abdominal, thoracic, cranial) without clear accidental trauma: **NO OVERLAP**.

- Multiple injuries or injuries at different stages of healing: **NO OVERLAP**.

- Injuries associated with signs of old wounds, fractures, or scars: **NO OVERLAP**.

- Injuries located in areas atypical for accidental trauma (e.g., chest, abdomen, back, buttocks, inner thighs): **NO OVERLAP**.

- Presence of other signs of abuse: bruises, burns, bite marks, cutaneous or mucosal injuries: **OVERLAP**. The words from this rule that are already mentioned in the rule we are considering are bruises, burns and bite marks, we will add cutaneous or mucosal injuries to the considered rule, that will become $\Rightarrow$ **'Presence of non-accidental physical injuries (bruises, fractures, burns, bites, ligature marks, abrasions, injuries from blunt or sharp objects, cutaneous or mucosal injuries, etc.)'**. We can now delete this rule from the group.

- Evidence of neglect or malnutrition: **NO OVERLAP**.

- Check for injuries at various stages of healing: **NO OVERLAP**.

- Bruises, fractures, burns, bite marks, ligature marks, genital/anal injuries: **OVERLAP** All the words from this rule overlap with the considered rule except the words 'genital/anal', but we don't want to add these words to our considered rule because they are more closely related to the second rule, and if we added those words, then our considered rule would then overlap with the second rule and become too long and complex. The solution is to delete only the the words that we already dealt with, and keep the updated rule, which will only contain 'genital/anal injuries' and in the next iteration we will examine its relationship with the second rule.

- special attention to atypical areas (chest, back, buttocks, back of the legs: **NO OVERLAP**.

We've now considered only the first rule of the first group. We proceed to consider the second rule of the updated first group. This is an iterative process where the group is progressively made smaller.

After finishing all the rules of the first group we repeat the process with the second group and so on.

At the end of this process, we will have the same amount of groups but internally they will be shorter.

Now the second process starts, here we want to eliminate the inter-group overlap. We don't want the rules to be duplicated in different groups, we want to achieve a structure in which one rule belongs to one group and one group only. To achieve this, we have two options:

1. if the rule is composed, that is, if the rule is made up of two or more rules that belong to different categories, then we can divide the composed rule and put each part in the category in which it belongs. We saw previously an example of this case with the rule *'Injuries of different ages or in unusual locations.'*. This rule can be split into two rules: *'Injuries of different ages'* which belongs in the category **'Inconsistent or recurring injuries'**; and rule *'Injuries in unusual locations'* which belongs to the category **'Nature of the injury'**.

2. if a rule is not composed, but still belongs to two or more categories, than we will merge the involved groups to create one maxigroup. An example of this is the previously mentioned case of the rule *'Direct or indirect accounts of violence or abuse.'* which is not a composition of multiple rules, but it belongs to two groups: **'Abnormal behavior in the child'** and **'Abnormal behavior in caregivers'**. In this case we will merge the two categories to create the maxicategory **'Abnormal behavior in the child or in the caregivers'**.

4.3.3 Final structure of the rules

1. **Characteristics, Consistency and Recurrence of the injuries:**

    - Presence of non accidental physical injuries (bruises, fractures, burns, bite marks, ligature marks, abrasions, burns, bites, injuries from blunt or sharp objects, cutaneous or mucosal injuries, etc.).
    - Physical signs of sexual abuse (genital/anal injuries, sexually transmitted infections).
    - Fractures in locations typically associated with abuse (e.g., posterior ribs, metaphyses, scapula, sternum, vertebrae).
    - Fractures in non-ambulatory children (e.g., infants).
    - Internal injuries (hemorrhages, visceral injuries, abdominal, thoracic, cranial) not explained by the provided history, with no clear accidental trauma.
    - Injuries in atypical areas (chest, abdomen, back, buttocks, inner thighs, ears, neck, mucous membranes, back of the legs).
    - Multiple injuries, symmetric injuries, or injuries of different ages, at different stages of healing.
    - Injuries with recognizable shapes (e.g., imprint of objects, belts, hands, teeth).
    - Absence of explanation or vague, contradictory, changing or implausible explanation for the injuries observed, or for the child's motor development or age.

2. **Delayed medical care seeking:**

    - Delayed access to healthcare relative to the severity of the injury.
    - Unjustified delay between the alleged trauma and the request for medical assistance, without a plausible explanation or with vague/inconsistent explanations.

- Failure to provide the necessary medical care.

3. **Signs of neglect:**

   - Signs of neglect, malnutrition, poor hygiene, growth delay, inappropriate clothing.

4. **Inconsistent medical history:**

   - History of repeated emergency visits or medical consultations for trauma or injuries.
   - Previous reports of suspected abuse or maltreatment.
   - Absent, vague, contradictory, or clinically incompatible medical history
   - Frequent changes in the doctor or healthcare facility.

5. **Abnormal behavior in the child or in the caregivers:**

   - Regression, early sexualization, withdrawal, aggression, fear, excessive quietness, abnormal behavior (child).
   - Fear or avoidance of certain people or places, unmotivated fear, hypervigilant attitude (child).
   - Sudden behavioral or emotional changes (child).
   - Signs of emotional or behavioral disorders without apparent cause (child).
   - Physical or emotional neglect (lack of affection) (caregiver).
   - Harmful overprotection or excessive care (caregiver).
   - Defensive, hostile, excessively anxious, or uncooperative attitude (caregiver).
   - Direct or indirect accounts of violence or abuse.

4.4 Convert rules into logical formulas

For each group we will link each rule belonging to the group with the OR operator, that is, if even one of the rules that belong to the given group is TRUE, then the group will be TRUE. A group that is TRUE will give rise to the suspicion of abuse (NAP), this can be described in mathematical terms as follows.

$$\left(\bigvee_{i=1}^{n} \text{Rule}_i\right) \Rightarrow \text{Group}_j \Rightarrow \text{NAP}$$

To better understand this formula, in these subsections we will implement the logical operations in detail, for each group.

Characteristics, Consistency and Recurrence of the injuries

> **IF** ((Presence of non accidental physical injuries (bruises, fractures, burns, bite marks, ligature marks, abrasions, burns, bites, injuries from blunt or sharp objects, cutaneous or mucosal injuries, etc.))
>
> **OR** (Physical signs of sexual abuse (genital/anal injuries, sexually transmitted infections))
>
> **OR** (Fractures in locations typically associated with abuse (e.g., posterior ribs, metaphyses, scapula, sternum, vertebrae))
>
> **OR** (Fractures in non-ambulatory children (e.g., infants))
>
> **OR** (Internal injuries (hemorrhages, visceral injuries, abdominal, thoracic, cranial) not explained by the provided history, with no clear accidental trauma)
>
> **OR** (Injuries in atypical areas (chest, abdomen, back, buttocks, inner thighs, ears, neck, mucous membranes, back of the legs))
>
> **OR** (Multiple injuries, symmetric injuries, or injuries of different ages, at different stages of healing)

OR (Injuries with recognizable shapes (e.g., imprint of objects, belts, hands, teeth))

OR (Absence of explanation or vague, contradictory, changing or implausible explanation for the injuries observed, or for the child's motor development or age))

$\Rightarrow$ (Characteristics, Consistency and Recurrence of the injuries)

Delayed medical care seeking

IF ((Delayed access to healthcare relative to the severity of the injury)

OR (Unjustified delay between the alleged trauma and the request for medical assistance, without a plausible explanation or with vague/inconsistent explanations)

OR (Failure to provide the necessary medical care))
$\Rightarrow$ (Delayed medical care seeking)

Signs of neglect

IF (Signs of neglect, malnutrition, poor hygiene, growth delay, inappropriate clothing)
$\Rightarrow$ (Signs of neglect)

Inconsistent medical history

IF ((History of repeated emergency visits or medical consultations for trauma or injuries)

OR (Previous reports of suspected abuse or maltreatment)

OR (Absent, vague, contradictory, or clinically incompatible medical history)

OR (Frequent changes in the doctor or healthcare facility))
⇒ (Inconsistent medical history)

Abnormal behavior in the child or in the caregivers

IF ((Regression, early sexualization, withdrawal, aggression, fear, excessive quietness, abnormal behavior (child))

OR (Fear or avoidance of certain people or places, unmotivated fear, hypervigilant attitude (child))

OR (Sudden behavioral or emotional changes (child))

OR (Signs of emotional or behavioral disorders without apparent cause (child))

OR (Physical or emotional neglect (lack of affection) (caregiver))

OR (Harmful overprotection or excessive care (caregiver))

OR (Defensive, hostile, excessively anxious, or uncooperative attitude (caregiver))

OR (Direct or indirect accounts of violence or abuse))
⇒ (Abnormal behavior in the child or in the caregivers)

Resulting formula:

IF ((Characteristics, Consistency and Recurrence of the injuries)

OR (Delayed medical care seeking)

OR (Signs of neglect)

OR (Inconsistent medical history)

OR (Abnormal behavior in the child or in the caregivers))
⇒ SuspectAbuse (NAP)

4.5 From logical formulas to Prolog rules

After defining the logical formulas, in this section we will translate them into the Prolog language, which allows to create predicates and query over the conditions that are defined by the cases.

The format of the logical formulas that we defined in the previous section (section 4.4) already closely resembles Prolog syntax. For each logical formula we will define one Prolog predicate, that means that we will have a Prolog predicate that encompasses the **'Characteristics, Consistency and Recurrence of the injuries'** group, one Prolog predicate for the **'Delayed medical care seeking'** group, and so on.

Characteristics, Consistency and Recurrence of the injuries

```
characteristics_consistency_recurrence_of_injuries
:-
   non_accidental_physical_injuries;
   physical_signs_of_sexual_abuse;
   fractures_in_locations_typically_associated_with_abuse;
   fractures_in_non_ambulatory_children;
   unexplained_internal_injuries;
   injuries_in_atypical_areas;
   multiple_symmetric_or_injuries_of_different_ages_or_stages;
   injuries_recognizable_shape;
   inconsistent_or_changing_explanations.
```

Delayed medical care seeking

```
delayed_medical_care_seeking :-
   delayed_access_relative_to_severity;
   unjustified_delay_between_trauma_and_request_for_medical_assistance;
```

```
    failure_to_provide_necessary_medical_care.
```

Signs of neglect

```
signs_of_neglect :-
    signs_of_neglect;
    malnutrition;
    poor_hygiene;
    growth_delay;
    inappropriate_clothing.
```

Inconsistent medical history

```
inconsistent_medical_history :-
    repeated_visits_for_trauma_or_injuries;
    previous_abuse_or_maltreatment_reports;
    absent_vague_ contradictory_or_incompatible_history;
    frequent_doctor_or_facility_changes.
```

Abnormal behavior in the child or in the caregivers

```
abnormal_behavior_in_child_or_caregivers :-
    regression_early_sexualization_withdrawal_aggression_fear_excessive
quietness_abnormal_behavior;
    fear_avoidance_of_people_or_places_hypervigilant_attitude;
    sudden_behavioral_or_emotional_changes;
    unexplained_emotional_or_behavioral_disorders;
    physical_or_emotional_neglect;
    overprotection_or_excessive_care;
```

```
    defensive_hostile_anxious_uncooperative;
    direct_indirect_accounts_of_violence_or_abuse.
```

Final Suspicion of Abuse rule

```
suspect_abuse :-
    characteristics_consistency_recurrence_of_injuries;
    delayed_medical_care_seeking;
    signs_of_neglect;
    inconsistent_medical_history;
    abnormal_behavior_in_child_or_caregivers.
```

Chapter 5

Rules Validation

Following the examples of the ESCAPE solution and the SCAN methodology, we decided to try to use the rules we extracted before, to create a comprehensive questionnaire that fits the Italian manuals.

5.1 Procedure

Since in chapter 4.4 we defined 5 groups of rules, and we traced the logic connections that define their relationships, we will start by working directly with the groups, rather than with the single rules.

We recall the last logical rule we defined:

IF ((Characteristics, Consistency and Recurrence of the injuries)

OR (Delayed medical care seeking)

OR (Signs of neglect)

OR (Inconsistent medical history)

OR (Abnormal behavior in the child or in the caregivers))

$\Rightarrow$ SuspectAbuse (NAP)

Given this rule we can trace back to the question that we have to ask, in order to get a positive or negative response that describes the state of any of these defined groups, that way, by answering the formulated question, we would have a direct logical link to the state of the Suspected Abuse (NAP) i.e. either if there there is a suspicion or not.

CHARACTERISTICS, CONSISTENCY AND RECURRENCE OF THE INJURIES

This group encompasses the largest group of rules, regarding the nature, location, type, origins of injuries, along with their recurrence, and the consistency of the explanation in contraposition with the actual observation of the injury.

Here are the rules that make up the group:

> **IF** ((Presence of non accidental physical injuries (bruises, fractures, burns, bite marks, ligature marks, abrasions, burns, bites, injuries from blunt or sharp objects, cutaneous or mucosal injuries, etc.))
>
> **OR** (Physical signs of sexual abuse (genital/anal injuries, sexually transmitted infections))
>
> **OR** (Fractures in locations typically associated with abuse (e.g., posterior ribs, metaphyses, scapula, sternum, vertebrae))
>
> **OR** (Fractures in non-ambulatory children (e.g., infants))
>
> **OR** (Internal injuries (hemorrhages, visceral injuries, abdominal, thoracic, cranial) not explained by the provided history, with no clear accidental trauma)
>
> **OR** (Injuries in atypical areas (chest, abdomen, back, buttocks, inner thighs, ears, neck, mucous membranes, back of the legs))
>
> **OR** (Multiple injuries, symmetric injuries, or injuries of different ages, at different stages of healing)

OR (Injuries with recognizable shapes (e.g., imprint of objects, belts, hands, teeth))

OR (Absence of explanation or vague, contradictory, changing or implausible explanation for the injuries observed, or for the child's motor development or age))

So the question or questions to pose should encompass or reference all of these points:

1. Characteristics:
    - non-accidental injuries
    - signs of sexual abuse
    - atypical location
    - internal injuries
    - recognizable shape
2. Consistence:
    - incompatible explanation
3. Recurrence:
    - multiple injuries in different stages of healing

Here are the proposed questions:

1. **Are the injuries non-accidental, consistent with sexual abuse, in an atypical location, in an internal location, do they have a recognizable shape or are they in different stages of healing?** (check yes if any of these are true).
2. **Is the explanation given vague, changing, or incompatible with the observed injury?**

These questions will then substitute the abstract rule:

> **IF** ((Characteristics, Consistency and Recurrence of the injuries)
> ⇒ SuspectAbuse (NAP)

turning it into its formulated form:

> **IF** ((There are non-accidental injuries, **or** injuries consistent with sexual abuse, **or** in an atypical location, **or** in an internal location, **or** do they have a recognizable shape **or** are they in different stages of healing?)
>
> **OR** (Is the explanation given vague, changing, or incompatible with the observed injury?))
>
> ⇒ SuspectAbuse (NAP)

This questions encompass the extracted rules, as shown in the following example.

Let's suppose that in a specific case, a non-ambulatory child presents a fractured leg. Then the answer of the first question would be:

> Are the injuries non-accidental? False,
> Are the injuries consistent with sexual abuse? False,
> Are the injuries in an atypical location? False,
> Are the injuries in an internal location? False,
> Do the injuries have a recognizable shape? False,
> Are the injuries in different stages of healing? False,

Question 1's answer is False or False or ... or False => False, lets move onto question 2.
Is the explanation given vague, changing, or incompatible with the observed injury? True (a leg fraction in a non-ambulatory child is incompatible with the child falling on his own, as he isn't capable of walking yet)

That would set SuspectAbuse(NAP) to true:

IF ((Are the injuries non-accidental, **or** consistent with sexual abuse, **or** in an atypical location, **or** in an internal location, **or** do they have a recognizable shape **or** are they in different stages of healing?) = **FALSE**

OR (Is the explanation given vague, changing, or incompatible with the observed injury?)) = **TRUE**
⇒ SuspectAbuse (NAP) = **TRUE**

DELAYED MEDICAL CARE SEEKING

The **'Delayed medical care seeking'** group, is composed of three rules, which deal with cases where there was either a latency or complete disregard from the caregiver to provide the child with adequate medical care in an appropriate amount of time.
Here are the rules that make up the group:

IF ((Delayed access to healthcare relative to the severity of the injury)

OR (Unjustified delay between the alleged trauma and the request for medical assistance, without a plausible explanation or with vague/inconsistent explanations)

OR (Failure to provide the necessary medical care))
⇒ (Delayed medical care seeking) ⇒ SuspectAbuse(NAP)

The proposed question is:
Was there an unjustified delay or failure in providing medical care?
Here is the updated rule:

IF (There was an unjustified delay in providing medical care **or** a failure to provide medical care)
⇒ SuspectAbuse(NAP)

Now we test this logical formula with an example. We suppose that a child gets to the E.R. with a broken arm, and the parents explain that he fell a week ago, but didn't feel too much pain, so they thought it wasn't broken.
The answers to the question should be:

> Was there an unjustified delay in providing medical care? True,
> Was there a failure to provide medical care? False

We substitute the answers into our new formula.

> **IF** (There was an unjustified delay in providing medical care **or** a failure to provide medical care) = **TRUE**
> ⇒ SuspectAbuse(NAP) = **TRUE**

SIGNS OF NEGLECT

This group is fairly simple, with straightforward rules. We expect to have a single short question that encompasses the different aspects of the rule.
Here is the rule the question will consider:

> **IF** (Signs of neglect, malnutrition, poor hygiene, growth delay, inappropriate clothing)

Here is the proposed question:
Does the child present signs of neglect, malnutrition, poor hygiene, growth delay or inappropriate clothing?
The new abstract rule is:

> **IF** (the child presents signs of neglect **or** malnutrition, **or** poor hygiene, **or** growth delay **or** inappropriate clothing)
> ⇒ SuspectAbuse (NAP)

Let's test if this question correctly sets SuspectAbuse as true or false with an example:

Let's suppose that a child enters the E.R. wearing a T-shirt and shorts in December. The answers of the question should be:

Does the child present signs of neglect? False,
Does the child present signs of malnutrition? False,
Does the child present signs of poor hygiene? False,
Does the child present signs of growth delay? False,
Does the child present signs of inappropriate clothing? True, in Italy, it's winter in December, so the child should be wearing heavy clothing.

Now we substitute this answers in our logical formula as follows.

IF (the child presents signs of neglect **or** malnutrition, **or** poor hygiene, **or** growth delay **or** inappropriate clothing) = **TRUE**
$\Rightarrow$ SuspectAbuse (NAP) = **TRUE**

INCONSISTENT MEDICAL HISTORY

The **'Inconsistent medical history'** group of rules, deals with cases in which the medical history of the patient is unusual, with frequent emergency visits, injuries, changes, vague explanations, etc...

Here are the logical rules defined in Chapter 4.4, regarding this group.

IF ((History of repeated emergency visits or medical consultations for trauma or injuries)
OR (Previous reports of suspected abuse or maltreatment)
OR (Absent, vague, contradictory, or clinically incompatible medical history)
OR (Frequent changes in the doctor or healthcare facility))
$\Rightarrow$ (Inconsistent medical history) $\Rightarrow$ SuspectAbuse (NAP)

The proposed question should encompass the following aspects quoted in the group's rules:

- repeated medical visits related to injuries
- reports of suspected abuse/maltreatment
- vague or incompatible medical history
- multiple doctor or facility changes

Here is the proposed question:
Does the medical history show repeated medical visits for injuries, previous reports of suspected abuse/maltreatment, frequent changes in doctors or facilities, or is the history vague or contradictory? (check yes if any of these are true)

Here is the resulting logical rule after substituting the extracted rules with our question.

> **IF** (the medical history shows repeated medical visits for injuries, **or** previous reports of suspected abuse or maltreatment, **or** frequent changes in doctors or facilities, **or** the history is vague or contradictory)
> $\Rightarrow$ SuspectAbuse (NAP)

Now we test this new logical rule with an example of a case: Given a case in which a child enters the ED with a broken arm, and in logging their information to the hospital's database, the doctors come across various previous ED visits in which the child was admitted with a broken leg the previous year, a broken finger the year before, and so on, then the answers to the proposed question would steer the logical rule in the following way:

> Does the medical history show repeated medical visits for injuries? True

Does the medical history show previous reports of suspected abuse or maltreatment? False

Does the medical history show frequent changes in doctors or facilities? False

Is the medical history vague or contradictory? False

By substituting these answers in the logical formula, we see that the suspect of abuse is set to true:

IF (the medical history shows repeated medical visits for injuries, **or** previous reports of suspected abuse or maltreatment, **or** frequent changes in doctors or facilities, **or** the history is vague or contradictory) = **TRUE**

$\Rightarrow$ SuspectAbuse (NAP) = **TRUE**

ABNORMAL BEHAVIOR IN THE CHILD OR IN THE CAREGIVERS

The **'Abnormal behavior in the child or in the caregivers'** group of rules deals with all the aspects of the child's behavior and of the caregiver's behavior that could give rise to the suspicion of abuse.

Here is the logical rule that we defined in Chapter 4.4 that deals with this group.

IF ((Regression, early sexualization, withdrawal, aggression, fear, excessive quietness, abnormal behavior (child))

OR (Fear or avoidance of certain people or places, unmotivated fear, hypervigilant attitude (child))

OR (Sudden behavioral or emotional changes (child))

OR (Signs of emotional or behavioral disorders without apparent cause (child))

OR (Physical or emotional neglect (lack of affection) (caregiver))

OR (Harmful overprotection or excessive care (caregiver))

OR (Defensive, hostile, excessively anxious, or uncooperative attitude (caregiver))

OR (Direct or indirect accounts of violence or abuse))
$\Rightarrow$ (Abnormal behavior in the child or in the caregivers) $\Rightarrow$ SuspectAbuse (NAP)

Now let's highlight the key words the question should cover:

1. Child's behavior:
    - abnormal
    - fear, avoidance
    - sudden changes
    - behavioral disorders
2. Caregiver behavior:
    - neglect
    - overprotection
    - uncooperative, defensive or anxious
3. Child or caregiver's behavior:
    - account of violence

The proposed question is:

Does the child or the caregiver show abnormal behavior, such as fear, avoidance, sudden emotional or behavioral changes, neglect, excessive care, hostility, or have there been any direct or indirect accounts of violence? (check yes if any of these is true)

Here is the updated logical rule:

> **IF** (The child or the caregiver show abnormal behavior, such as fear, avoidance, sudden emotional or behavioral changes, neglect, excessive care, hostility, **or if** there was a direct or indirect account of violence)
>
> $\Rightarrow$ SuspectAbuse (NAP)

Now we'll consider the following case example: A child enters the E.R. with his mother, while the mother explains the injury and the child answers check-up questions, the child's father enters the room and the child falls quiet.

Here is how the proposed questions should be answered in this case:

> Does the child or the caregiver show abnormal behavior? True
> Does the child or the caregiver show fear? True
> Does the child or the caregiver show avoidance? False
> Does the child or the caregiver show sudden emotional or behavioral changes? True
> Does the caregiver show neglect? False
> Does the caregiver show excessive care? False
> Does the caregiver show hostility? False
> Have there been any direct or indirect accounts of violence? False

Here is the result of the logical formula, considering the given case.

> **IF** (The child or the caregiver show abnormal behavior, such as fear, avoidance, sudden emotional or behavioral changes, neglect, excessive care, hostility, **or if** there was a direct or indirect account of violence) = **TRUE**
>
> $\Rightarrow$ SuspectAbuse (NAP) = **TRUE**

RESULTING FORMULA

IF ((There are non-accidental injuries, **or** there are injuries consistent with sexual abuse, **or** in an atypical location, **or** in an internal location, **or** the injuries have a recognizable shape **or** they are in different stages of healing)

OR (The explanation given is vague, changing, or incompatible with the observed injury))

OR (There was an unjustified delay in providing medical care **or** a failure to provide medical care)

OR (the child presents signs of neglect **or** malnutrition, **or** poor hygiene, **or** growth delay **or** inappropriate clothing)

OR (the medical history shows repeated medical visits for injuries, **or** previous reports of suspected abuse or maltreatment, **or** frequent changes in doctors or facilities, **or** the history is vague or contradictory)

OR (The child or the caregiver show abnormal behavior, such as fear, avoidance, sudden emotional or behavioral changes, neglect, excessive care, hostility, **or if** there was a direct or indirect account of violence)
$\Rightarrow$ SuspectAbuse (NAP)

5.2 The questions

The questions obtained from the process described in the previous section are:

1. Are the injuries non-accidental, consistent with sexual abuse, in an atypical location, in an internal location, do they have a recognizable shape or are they in different stages of healing? (check yes if any of these are true)

2. Is the explanation given vague, changing, or incompatible with the observed injury?

3. Was there an unjustified delay or failure in providing medical care?

4. Does the child present signs of neglect, malnutrition, poor hygiene, growth delay or inappropriate clothing? (check yes if any of these are true)

5. Does the medical history show repeated medical visits for injuries, previous reports of suspected abuse/maltreatment, frequent changes in doctors or facilities, or is the history vague or contradictory? (check yes if any of these are true)

6. Does the child or the caregiver show abnormal behavior, such as fear, avoidance, sudden emotional or behavioral changes, neglect, excessive care, hostility, or have there been any direct or indirect accounts of violence? (check yes if any of these are true)

Now we will compare our questionnaire with the ESCAPE questions and the SCAN questions. We want to see if they range over the same themes, cover the same scope, and overall see how similar they are, and see if there are some good practices that we can learn from the ESCAPE and the SCAN questionnaires, that would be useful to incorporate into our own questionnaire.

5.3 Comparison

We can observe that across the different questionnaires there are some similar questions, and some similar themes, so we'll group the questions by theme and compare them one-to-one-to-one. We will follow the order defined by the ESCAPE questionnaire: for each ESCAPE question, we will identify the thematically corresponding questions from the other two questionnaires and proceed to their direct comparison.

To avoid confusion, each question will be associated with a number: ESCAPE questions will be n°1, SCAN questions will be n°2 and our questions will be n°3.

MEDICAL HISTORY

1. Is the history consistent?

2. Is the injury compatible with the history? (this is the first part of the larger SCAN question 'Is the injury compatible with the history, and does it correspond to the child's developmental level?'. We split that question into two questions, we moved the second half of the question to the category 'Injury characteristics'.)

3. Does the medical history show repeated medical visits for injuries, previous reports of suspected abuse/maltreatment, frequent changes in doctors or facilities, or is the history vague or contradictory?

Our question is long and detailed. It would be better to define a shorter more generic question, since the questionnaire is intended to be used frequently, we don't want it to be harder to read, unnecessarily detailed, but at the same time we don't want to omit useful information. The solution is to define a shorter and more generic question, and add a detailed note so that a doctor unfamiliar with the question's concept can be properly informed on what the consistence of the medical history entails.

Here is the new proposal of the question with the additional descriptive note:

> **Question:** "Is the history inconsistent?"
> **Description:** "Inconsistencies may include repeated medical visits for injuries, previous reports of suspected abuse or maltreatment, frequent changes in doctors or healthcare facilities, or vague or contradictory explanations."

DELAY

1. Was seeking medical help unnecessarily delayed?

2. Was there an unnecessary delay in seeking medical help? (Note: This refers specifically to the caregiver's delay, not the medical system's.)

3. Was there an unjustified delay or failure in providing medical care?

These questions are very similar. The ESCAPE and the SCAN questions have the same meaning and they are just written in inverse order.

Our question includes the two questions in the *"Was there an unjustified delay [...] in providing medical care?"* part of the questions, and adds *"or failure"*. That last part of the question includes cases in which there are observed older injuries that weren't treated, for example a broken bone that didn't heal properly, because of the failure to bring the child to the hospital at the time of the injury. Although our question is longer than the other two, it is not long enough to be cumbersome, so there is no need to shorten it. We will keep it as it is.

INJURY CHARACTERISTICS

1.
   - Are findings of the head-to-toe examination in accordance with the history?
   - Does the onset of the injury fit with the developmental level of the child?

2. Is the injury compatible with the history, and does it correspond to the child's developmental level?

3.
   - Are the injuries non-accidental, consistent with sexual abuse, in an atypical location, in an internal location, do they have a recognizable shape, or are they in different stages of healing? (check yes if any of these are true)

- Is the explanation given vague, changing, or incompatible with the observed injury?
- Does the child present signs of neglect, malnutrition, poor hygiene, growth delay or inappropriate clothing? (check yes if any of these are true)

Here we can see that the SCAN question merges both of the ESCAPE questions:

> Are findings of the head-to-toe examination in accordance with the history? ⇒ Is the injury compatible with the history [...]?
> Does the onset of the injury fit with the developmental level of the child? ⇒ [...] and does it correspond to the child's developmental level?

Our questions are more numerous and more detailed. Both the ESCAPE and the SCAN questions are contained in our questions:

> *"Is the explanation given vague, changing, or incompatible with the observed injury?"* in particular *"is the explanation incompatible with the observed injury?"* would be answered by answering the question *"Is the injury compatible with the history, and does it correspond to the child's developmental level?"*.
>
> Lets reformulate the SCAN question with its negation, so that we pose it the same way as our question:
>
> *"Is the injury compatible with the history, and does it correspond to the child's developmental level?"* ⇒ *"Is the injury incompatible with the history, or is the injury incompatible with the child's developmental level?"*.
>
> The question *"is the explanation incompatible with the observed injury?"* contains the questions *"Is the injury incompatible with*

the history, or is the injury incompatible with the child's developmental level?":

If a non-ambulatory child had a broken arm, *"Is the injury incompatible with the history, or is the injury incompatible with the child's developmental level?*" would be answered 'True', and *"is the explanation incompatible with the observed injury?"* would be also answered 'True'.

As is the case of the question regarding the medical history, we aim to keep a simpler, more concise question, accompanied by a detailed note. Here are the new proposed question and its description:

Question: "Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect?"

Description: "Injuries compatible with abuse may include injuries that are non-accidental, injuries that are consistent with sexual abuse, in an atypical location, in an internal location, or injuries that have a recognizable shape or that are in different stages of healing; Signs of neglect may include malnutrition, poor hygiene, growth delay, or inappropriate clothing."

BEHAVIOR

1. Is the behavior of the child, the carers, and their interaction appropriate?
2. Is the behavior/interaction of the child and parent(s) appropriate?
3. Does the child or the caregiver show abnormal behavior, such as fear, avoidance, sudden emotional or behavioral changes, neglect, excessive care, hostility, or have there been any direct or indirect accounts of violence? (check yes if any of these are true)

Our question is much longer and more detailed. It's not a bad thing to have an explicitly detailed question, but it becomes cumbersome in a questionnaire that will be used frequently. Therefore, as was the case of the previous questions, our approach is to simplify the question and add a descriptive note which can be quickly and easily reached if the doctor is less experienced in this specific medical field, or if the doctor is less familiar with what constitutes abnormal behavior in the child or in the caregiver.

Lets update the question the following way:

> **Question:** "Is the behavior/interaction of the child and parent(s) inappropriate?"
>
> **Description:** "Inappropriate or abnormal behavior may include fear, avoidance, sudden emotional or behavioral changes, neglect, excessive care, hostility, or direct/indirect accounts of violence."

OTHERS

1. Are there other signals that make you doubt the safety of the child or other family members?

2. Are there other signals that make you doubt the safety of the child and/or family?

These are some good questions that highlight the importance of an experienced doctor's instinct. It wouldn't harm to add it to our questions, as it would add a level of safety that relies on an unexplainable feeling that the doctor may have. It covers a space that our questions don't cover.

Therefore, we will add to our questionnaire the question: "Are there other signals that make you doubt the safety of the child and/or family?"

In the following table, table 5.1, we show the direct comparison of the questions in the three questionnaires, along with the resulting question, with its corresponding description that we will use in the final checklist.

ESCAPE	SCAN	Ours	Result
Is the history consistent?	Is the injury compatible with the history?	Does the medical history show repeated medical visits for injuries, previous reports of suspected abuse/maltreatment, frequent changes in doctors or facilities, or is the history vague or contradictory?	**Q:**Is the history inconsistent? **D:** Inconsistencies may include repeated medical visits for injuries, previous reports of suspected abuse or maltreatment, frequent changes in doctors or healthcare facilities, or vague or contradictory explanations.
Was seeking medical help unnecessarily delayed?	Was there an unnecessary delay in seeking medical help? (Note: This refers specifically to the caregiver's delay, not the medical system's.)	Was there an unjustified delay or failure in providing medical care?	**Q:** Was there an unjustified delay or failure in providing medical care?
Are findings of the head-to-toe examination in accordance with the history? Does the onset of the injury fit with the developmental level of the child?	Is the injury compatible with the history, and does it correspond to the child's developmental level?	Are the injuries non-accidental, consistent with sexual abuse, in an atypical location, in an internal location, do they have a recognizable shape, or are they in different stages of healing? Is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect, malnutrition, poor hygiene, growth delay or inappropriate clothing?	**Q:** Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **D:** Injuries compatible with abuse may include injuries that are non-accidental, injuries that are consistent with sexual abuse, in an atypical location, in an internal location, or injuries that have a recognizable shape or that are in different stages of healing; Signs of neglect may include malnutrition, poor hygiene, growth delay, or inappropriate clothing.

ESCAPE	SCAN	Ours	Result
Is the behavior of the child, the carers, and their interaction appropriate?	Is the behavior/interaction of the child and parent(s) appropriate?	Does the child or the caregiver show abnormal behavior, such as fear, avoidance, sudden emotional or behavioral changes, neglect, excessive care, hostility, or have there been any direct or indirect accounts of violence?	**Q:** Is the behavior/interaction of the child and parent(s) inappropriate? **D:** Inappropriate or abnormal behavior may include fear, avoidance, sudden emotional or behavioral changes, neglect, excessive care, hostility, or direct/indirect accounts of violence.
Are there other signals that make you doubt the safety of the child or other family members?	Are there other signals that make you doubt the safety of the child and/or family?	-	**Q:** Are there other signals that make you doubt the safety of the child and/or family?

Table 5.1: Comparison of Questions from the ESCAPE, SCAN, and our questionnaires, along with reformulated questions (Q) and descriptions (D) used in our study

5.4 Final Checklist

The resulting questions and explanations will make up the final checklist.

The final checklist will look like this:

Question 1: Is the history inconsistent?

Description 1: Inconsistencies may include repeated medical visits for injuries, previous reports of suspected abuse or maltreatment, frequent changes in doctors or healthcare facilities, or vague or contradictory explanations.

Question 2: Was there an unjustified delay or failure in providing medical care?

Question 3: Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect?

Description 3: Injuries compatible with abuse may include injuries that are non-accidental, injuries that are consistent with sexual abuse, in an atypical location, in an internal location, or injuries that have a recognizable shape or that are in different stages of healing; Signs of neglect may include malnutrition, poor hygiene, growth delay, or inappropriate clothing.

Question 4: Is the behavior/interaction of the child and parent(s) inappropriate?

Description 4: Inappropriate or abnormal behavior may include fear, avoidance, sudden emotional or behavioral changes, neglect, excessive care, hostility, or direct/indirect accounts of violence.

Question 5: Are there other signals that make you doubt the safety of the child and/or family?

This tool is meant to respect fairness and equality.

While considering the third question there is a need to pay particular attention while observing bruises and ematomas in children with darker skin.

While considering the fourth question it is required that the doctor takes into account possible cultural or social differences.

It is crucial to have a translator present when required, in order to avoid misinterpretations.

5.4.1 Mock-ups

We've made up a few mock-ups to simulate how a doctor would interact with our checklist. The idea is to have a simple and short questionnaire that the doctors that will use the checklist frequently can compile in a quick fashion, and the doctors that use it infrequently can consult it in an exhaustive manner, checking symptom by symptom by reading the detailed descriptions provided.

Therefore, the first screen, figure 5.1, shows the five short questions, each accompanied by a button that can be selected (green) or left unselected (gray) depending on the True (green) or False (gray) answer to the question, and a downwards arrow that when clicked will extend the question's section's space to include the question's description. In this figure the questions are not extended to include their descriptions. We imagine that this is the view most often used by the doctors that already know the meaning of the questions and the details of the symptoms to look out for. They can quickly read the questions, check them if that is the case, and submit the questionnaire.

NOTE: Questions 2 and 5 don't have a downwards arrow because they don't need a description, since the questions are clear enough.

The second mock-up, figure 5.2, shows the view when the first question's downwards arrow has been clicked. Now the space underneath the first question has been extended and there the description corresponding to the first question is shown. That is, the question **"Is the history inconsistent?"** is followed by the explanation **"Inconsistencies may include repeated medical**

visits for injuries, previous reports of suspected abuse or maltreatment, frequent changes in doctors or healthcare facilities, or vague or contradictory explanations.".

The third mock-up, figure 5.3, extends question 3 **"Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect?"**; to include its explanation **"Injuries compatible with abuse may include injuries that are non-accidental, injuries that are consistent with sexual abuse, in an atypical location, in an internal location, or injuries that have a recognizable shape or that are in different stages of healing; Signs of neglect may include malnutrition, poor hygiene, growth delay, or inappropriate clothing."**.

The fourth and final mock-up, figure 5.4, shows the description of question n°4. Question n°4 is **"Is the behavior/interaction of the child and parent(s) inappropriate?"**; and its description is: **"Inappropriate or abnormal behavior may include fear, avoidance, sudden emotional or behavioral changes, neglect, excessive care, hostility, or direct/indirect accounts of violence."**. When the description is showed the arrow displayed at the bottom of the section is turned upwards so that by clicking it again, the description will be hidden.

These mockups can be found online at Mockups Drive.

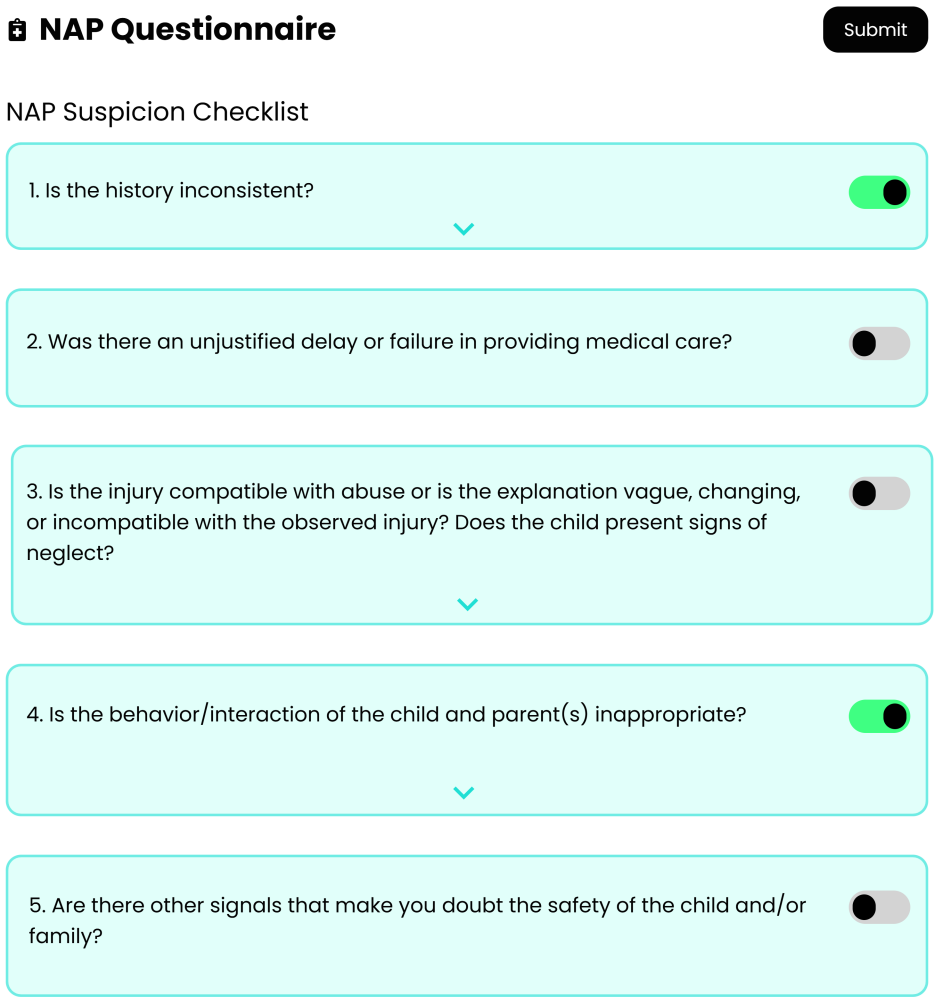

Figure 5.1: Mockup of the checklist with our 5 questions.

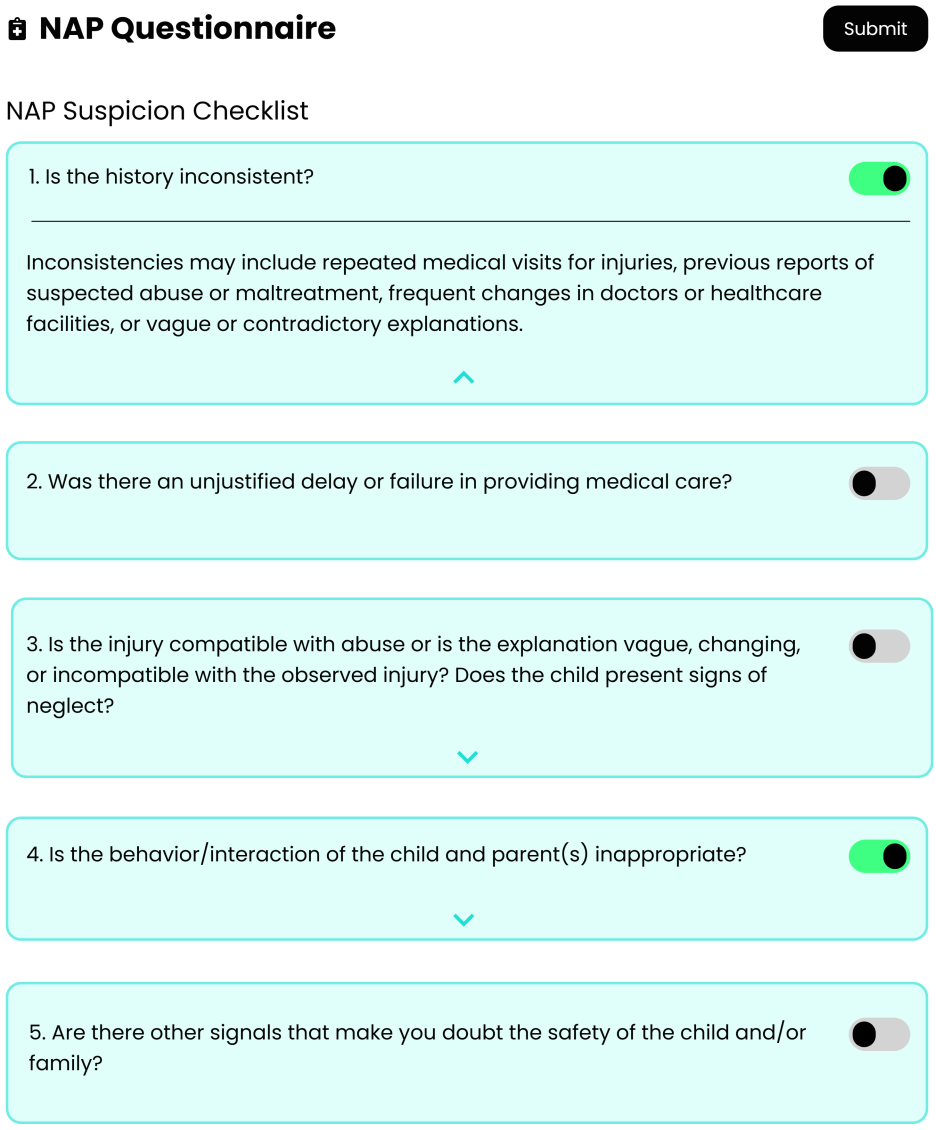

Figure 5.2: Mockup of the checklist after we clicked on the downwards arrow in question number 1, in order to see the description of question 1.

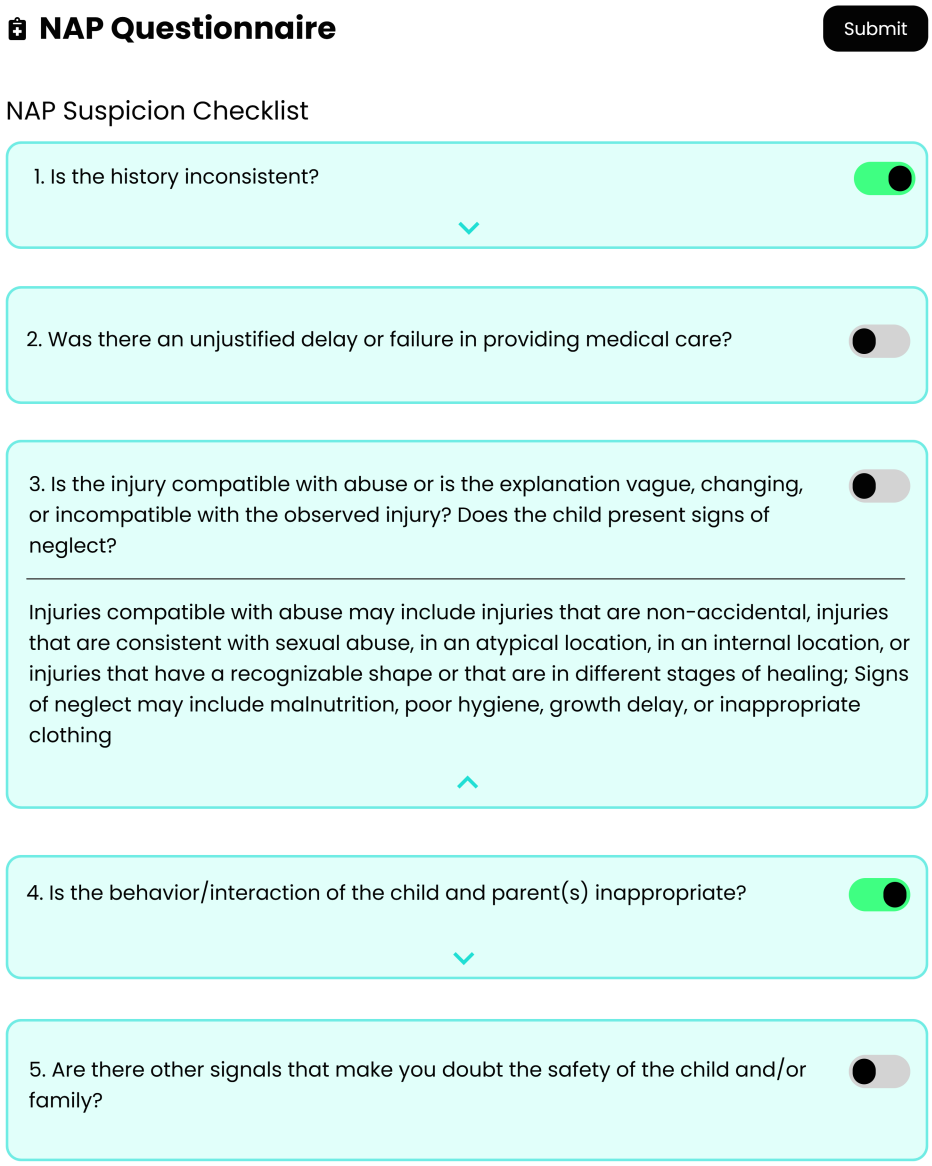

Figure 5.3: Mockup of the checklist after we clicked on the downwards arrow in question number 3.

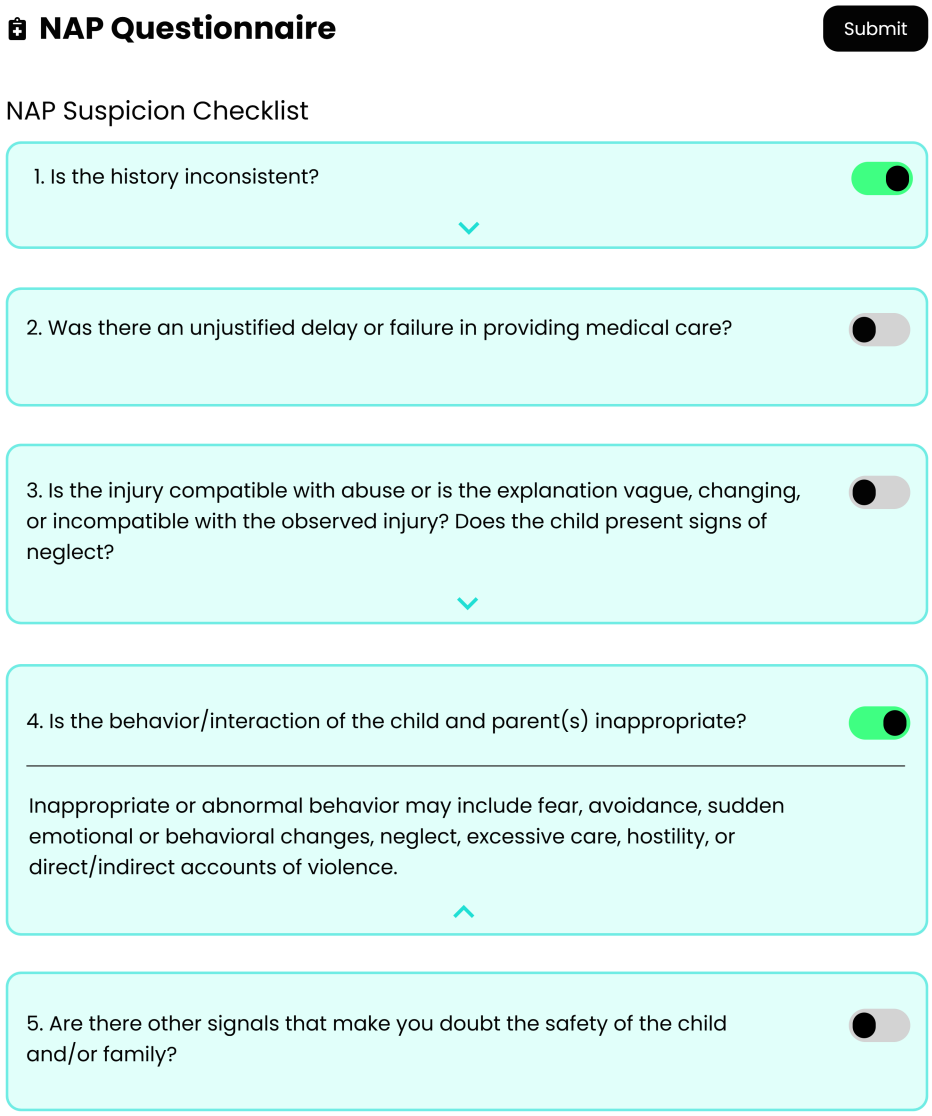

Figure 5.4: Mockup of the checklist after we clicked on the downwards arrow in question number 4, in order to see the description of question 4.

Chapter 6

Dataset Analysis - Experiments

In this chapter we will apply the questions from the checklist to the dataset kindly provided by the doctors of Sant'Orsola Hospital.

AIM

The aim of this chapter is to verify that our questionnaire works on real life cases. To do so, we will apply the checklist on a sample of nap-positive cases, and a sample of nap-negative samples, that is on a sample of cases that were previously flagged as positive in the classification of suspicion of abuse on a minor, and cases that were classified as negative on suspicion of abuse.

METHODOLOGY

Because we are dealing with sensitive information protected by privacy laws, only the necessary anonymized information will be shared in this chapter, that is a very simple and short recount of events, symptoms and explanations.

We will only report the leading symptom for each case, without diving deep into clinical exams and checkups that have returned normal results in each patient's case, that is both to protect confidential information, and because we only need the relevant symptoms to answer the questionnaire.

EXPECTATIONS

We aim to correctly classify each positive case as positive, and each negative case as negative.

This means that for every positive sample, we expect at least one question in our checklist to be answered as true. This way we can trust that our tool is capable of recognizing the signs of abuse in real cases, and could therefore support the doctors in identifying situations of potential abuse, and ultimately help children get out of an abusive situation.

For negative cases, we expect that all questions will be answered as false. This is important too, because, in a delicate real world context as this, false positives would have very serious consequences not only for the parents or caregivers involved, but also for the well-being of the child.

It's also worth noting that the dataset we're working with isn't ideal for this test. That is because the data is not structured in an optimal way for our questionnaire. The data contains the clinical context of the situation in which the patient enters the emergency department, along with clinical observations, but it doesn't offer insights on some key aspects that make up our checklist, for instance, in the dataset there are no reports of the doctor's impressions and observations of the child and the caregiver's behavior, or the doctor's personal 'feeling' of the potential unsafety of the child in their family environment.

Because of this, we expect the classification to be more challenging than it would be in a real use setting, where those observation would be reported as part of the process.

6.1 Manual Testing

6.1.1 Experiments on NAP cases

We will consider 17 positive abuse cases. For each case we will consider the logged symptoms, and simulate the answering of our checklist.

6.1.2 Case 1

The first case deals with the case of a child who's main symptoms were bruises and abrasions in his lower back, in his knee, arm and face. His mother also reported that the child told her that his teacher had hit him.
Therefore, the leading symptoms that we will consider while compiling our checklist are a direct account of violence and bruises in atypical locations.
The checklist is answered as follows:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **TRUE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **TRUE** (direct account of violence)

5. Are there other signals that make you doubt the safety of the child and/or

family? **FALSE**

Our checklist correctly identifies this case as suspected abuse.

Case 2

This case's main symptom is the direct account of violence given by the patient.
In this case, our checklist would be answered in the following way:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **FALSE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **TRUE** (direct account of violence)

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist correctly identifies this case as suspected abuse.

Case 3

The third case concerns a child who had multiple bruises and minor skin lesions. Specifically, small ecchymoses were observed on the right forearm, both sides of the lower back, left elbow, and signs of excoriation on the right ankle. Additional findings included a crusted lesion on the second toe of the right foot, a linear lesion in the right inguinal area, and generalized ligamentous laxity.

According to the child's mother, her son told her, that he'd been hit repeatedly by two classmates. The child also expressed an aversion to returning to school. The mother was cooperative, and no social obstacles to discharge were identified.

Therefore, the leading symptoms we will consider while compiling our checklist are bruises in atypical locations, multiple bruises at different stages of healing, a direct account of peer violence, and fear of going back to school.

The checklist is answered as follows:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **TRUE** (The injuries are compatible with abuse, they are in an atypical location, the injuries are in different stages of healing)

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **TRUE.** (the child gave a direct account of violence and showed signs

of avoidance at the idea of going back to school)

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist correctly identifies this case as suspected abuse.

Case 4

This is the case of a child that was brought to the hospital by his mother after seeing that he had a bruise under his left eye. The little boy and his sister told their mother that their father had slapped him repeatedly, causing a nosebleed. The leading symptoms are: an injury consistent with the child's explanation of abuse.

Here is the performance of this case on the checklist:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **TRUE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **TRUE** (direct recount of violence)

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist correctly classifies this case as suspected abuse.

Case 5

This is the case of a child who was hit by his father causing bruises on the upper back and arms, facial swelling, and petechiae under both eyes.

These are the answers to our checklist:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **TRUE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **TRUE** (direct recount of violence)

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist correctly classifies this case.

Case 6

In this case, the child, who suffers from Lennox-Gastaut syndrome and an intellectual disability, had a psychotic crisis after he witnessed violence perpetrated by his father against his mother and brother.

These are the checklist's answers:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **FALSE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **TRUE** (direct recount of violence, extreme distress of the child)

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist correctly classifies this case as suspected abuse.

Case 7

A baby exhibited abnormal tongue movements, incontrollable crying and irritability after her mother breastfed her after consuming cocaine.

These are the checklist's answers:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **TRUE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **TRUE** (direct recount of maltreatment, uncontrollable crying of the child, abnormal tongue movements)

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist correctly classifies this case as suspected abuse.

Case 8

The child was caught in the middle of a violent altercation between his father and another adult neighbor. A small, superficial skin abrasion was noted.
Here are the answers to the checklist:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **TRUE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **TRUE** (direct recount of violence)

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist correctly classifies this case as suspected abuse.

Case 9

The child was brought to the hospital after two classmates kicked her until her father shooed them away. The little girl showed a faint shoe imprint on her leggings at the left gluteal region. She reported localized pain in the left lumbar area when bending her torso, along with mild redness but no bruising or swelling.

Here are the answers to the checklist:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **TRUE** (signs of kicks)

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **TRUE** (direct recount of violence)

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist correctly classifies this case as suspected abuse.

Case 10

The child came into the hospital with small reddish bruises on the left cheek and neck area, a purplish bruise on the left earlobe, and a crusted abrasion on the left upper gluteal region. His mother reported that the incident took place while the child was spending the weekend in his father's custody, and that the child had told her that his father had slapped him. The child preferred not to speak to the doctors.

Here is the answers to the checklist:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **TRUE** (signs of slaps and bruises in atypical locations)

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **TRUE** (direct recount of violence, quietness of the child)

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist correctly classifies this case as suspected abuse.

Case 11

This case deals with a teenager that is terrified after a man threatened to kill him and his friend waving a metal bar, kicking his friend off his bicycle.

Here are the answers to the checklist:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **False**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **TRUE** (direct recount of violence, the child is terrified)

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist correctly classifies this case as suspected abuse.

Case 12

This case deals with a girl who reported being punched twice on the abdomen. She showed localized abdominal pain.
Here is the compiled checklist:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **TRUE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **TRUE** (direct recount of violence)

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist correctly classifies this case as suspected abuse.

Case 13

This case deals with a girl who reported being abused by her father but later said that it was a dream. The physical examination reported no signs of abuse.
Here is the compiled checklist:

1. Is the history inconsistent? **FALSE** (the explanation that it was a dream is consistent with the results of the gynecological examination)

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **TRUE** (the explanation is changing)

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **FALSE**

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist correctly classifies this case as suspected abuse, to be further investigated.

Case 14

This case involves a little girl who is autistic. She was brought to the hospital by her parents because they found multiple bruises after her return from school.

Here is the completed questionnaire:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **TRUE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **FALSE**

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist correctly classifies this case as suspected abuse.

Case 15

The child was brought to the hospital by his teacher because of 36 symmetric bruises on his back, arm and leg. His mother explained that it's a chinese technique to relive his stomach ache.

Here is the answers for the questions in our checklist:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **TRUE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **FALSE**

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist correctly classifies this case as suspected abuse for further investigations.

Case 16

The child was brought to the hospital by his mother after he told her upon his return from school that his teacher hurt him. The doctors recorded bruises on the left forearm, petecchiae in the elbow fold and a scratch near the right temple.

Here is how the checklist is answered:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child

present signs of neglect? **TRUE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **TRUE** (direct recount of violence)

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist correctly classifies this case as suspected abuse.

Case 17

A young girl was brought to the hospital by her mother for suspected abuse, after the mother saw signs of possible sexual abuse. The mother strongly argued against letting the girl stay in the hospital, going against the doctor's wishes. Here is the completed questionnaire:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **TRUE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **TRUE**

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist correctly classifies this case as suspected abuse.

6.1.3 Experiments on non NAP cases

In this subsection we will take into consideration 18 cases that were reported as no suspicion of abuse (non nap) by the Sant'Orsola Hospital's doctors. For each case we will briefly share the context, main symptoms and explanations, and then we will simulate the process of answering the questionnaire. Finally, based on those answers, we will see whether our checklist would classify the case as non nap, which is the expected result, or nap, which would mean that we generated a false positive, to be later addressed while evaluating the overall performance of our proposed tool.

Case 1

This is the case of a girl who was redirected to the hospital by her doctor for further evaluation of suspected abuse, because of the presence of a symptom that is compatible with both constipation and abuse. The physical exam performed at the hospital returned no injuries compatible with abuse. The girl did not show any signs of discomfort during examination.
Here are the answers to our questionnaire:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **FALSE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **FALSE.**

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist would not flag this case as suspected abuse, and that is consistent with the hospital's response.

Case 2

This case is about a girl that fell on the street. She shows an abrasion on the chin.
Here is how the questionnaire is answered:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **FALSE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **FALSE.**

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist correctly classifies this case as non nap.

Case 3

The teenager went to the hospital with abrasions and small injuries in his right arm and right leg. He was in the car with his father when his window shattered during a hailstorm.
Here are the answers to our questionnaire:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **FALSE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **FALSE.**

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist correctly classifies this case as non nap.

Case 4

A baby fell while trying to climb into his crib from the outside, while his parents were not present at 10pm. He was diagnosed with a minor frontal cranial trauma.
Here is the compiled checklist:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **FALSE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **FALSE**

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist classifies this case as non nap, in accordance with the non nap classification reported in the dataset.

Case 5

The young child was brought into the hospital because of a head injury, that is consistent with the explanation given which is that he fell from his mother's bed during the night.

Here is the compiled checklist:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **FALSE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **FALSE**

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist classifies this case as non nap.

Case 6

The child was brought to the Emergency Room because he broke his leg falling from his bicycle.
Here is the compiled checklist:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **FALSE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **FALSE**

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist classifies this case as non nap.

Case 7

A little girl went to the Hospital with a hematoma on her arm. She explains that she hit her arm against her desk.
Here is the compiled checklist:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **FALSE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **FALSE**

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist classifies this case as non nap.

Case 8

This case deals with a small burn on the foot. The child explains that a bit of boiling water fell while cooking pasta.
Here is the compiled checklist:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **FALSE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **FALSE**

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist correctly classifies this case as non nap.

Case 9

A little girl had an abrasion on her upper cheek. The mother explains she slipped while eating, and fell and hit her face against a table.

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **TRUE** (abrasion in an atypical location)

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **FALSE**

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist classifies this case as suspucion of nap, differently from the hospital's classification.

Case 10

A child was brought to the hospital because of a head trauma caused by falling from a sofa. He hit his forhead.
Here is the completed questionnaire:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **FALSE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **FALSE**

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

The checklist correctly suggests no suspicion of nap.

Case 11

A toddler was brought to the hospital because he hit his head falling from the bed at night, he shows no laceration just a light bump on the forehead.
Here are the answers to the checklist:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **FALSE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **FALSE**

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

The checklist correctly suggests no suspicion of nap.

Case 12

The boy had a head trauma that occurred when he climbed onto a 1 m high wall in a park and jumped off and fell and hit the back of his head.
Here are the answers to the checklist:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child

present signs of neglect? **FALSE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **FALSE**

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

The checklist correctly classifies this case as no suspicion of abuse.

Case 13

This case concerns a child presenting with a pruritic urticarial-like rash on the face, trunk, and limbs. The rash appeared in the afternoon after the child had spent time at the park.
Here is the compiled questionnaire:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **FALSE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **FALSE**

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

The checklist correctly classifies this case as no suspicion of abuse.

Case 14

This case deals with a child that displays a burn on the cheek, the little boy explains that he bumped his face into a hot stove while playing.
Here is the compiled checklist:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **TRUE** (burn in an atypical location)

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **FALSE**

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

Our checklist classifies this case as nap, differently from the hospital's classification.

Case 15

This is the case of a girl that has a swelling of the forehead, first brought to the pediatrician by her mother 15 days ago when she noticed it, and after a couple recurrent checkups the pediatrician sent her to the hospital.
Here are the answers to the checklist:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **FALSE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **FALSE**

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

The checklist correctly classifies this case as no suspicion of abuse.

Case 16

The child was brought to the the hospital because of an eczema.
Here are the answers to our questionnaire:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **FALSE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **FALSE**

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

The checklist correctly classifies this case as no nap.

Case 17

The child was brought to the emergency department for a burn caused by hot broth on the left wrist and forearm.
Here are the answers to our questionnaire:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child

present signs of neglect? **FALSE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **FALSE**

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

The checklist correctly classifies this case as no nap.

Case 18

This case concerns a child that fell from her bycicle and hurt her ankle, the ankle was swelled and had an abrasion.
Here is the compiled questionnaire:

1. Is the history inconsistent? **FALSE**

2. Was there an unjustified delay or failure in providing medical care? **FALSE**

3. Is the injury compatible with abuse or is the explanation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect? **FALSE**

4. Is the behavior/interaction of the child and parent(s) inappropriate?" **FALSE**

5. Are there other signals that make you doubt the safety of the child and/or family? **FALSE**

The checklist correctly classifies this case as no suspicion of abuse.

6.1.4 Analysis and observations on the manual results

The tests conducted on the positive suspect of abuse cases (nap) performed really well, all of the cases resulted in true positives, that means that all the cases that were flagged on the dataset as suspected abuse, corresponded to a checklist that had one or more TRUE answers. This is very good, because it means that, if we used our tool in real life, it wouldn't miss a positive case, it would recognize the signs of abuse correctly.

The tests conducted on the cases that the doctors classified as 'no nap', that is as 'no suspicion of abuse', returned two false positives, that means that at least one question of our checklist was answered as true in those two cases.

Those two cases are: case number 9, the case of the young girl who had an abrasion on the cheek, which while it was consistent with the explanation (falling and hitting her face on a table), it also was located in an atypical location; and case number 14, the case in which the child had a burn on his cheek.

To better visualize the results lets display them in a confusion matrix, figure 6.1.

6.2 Automatic Testing

6.2.1 Automated Testing

After manually simulating the tests described in the previous section, we proceeded to write a code to automatically test the remaining 21791 cases.

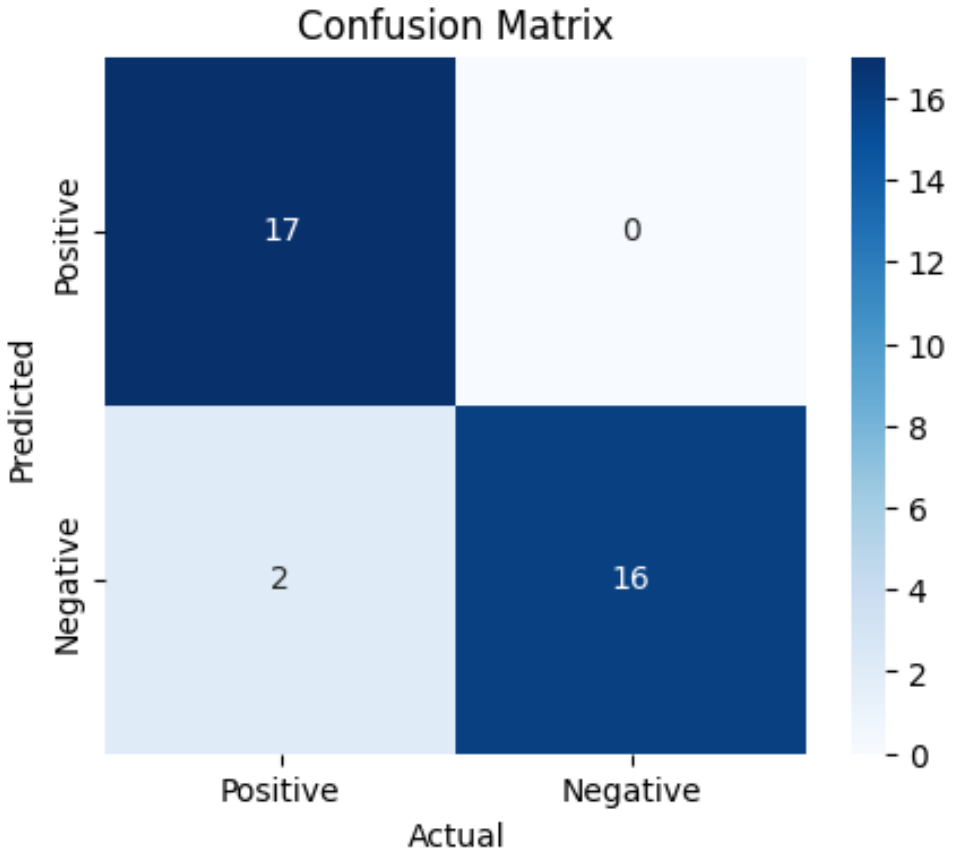

Figure 6.1: Confusion Matrix of the manual results. The true positives are 17/17, the true negatives are 16/18, the false positives are 2.

Zero-Shots Testing

Initially we tested all the cases with zero-shots.

We defined the following prompt:

> ”Leggi il seguente testo clinico e compila la checklist qui sotto.
> Per ogni domanda rispondi solo con TRUE o FALSE.
> TESTO CLINICO: **testo_caso**
> CHECKLIST:
> 1. La storia clinica è incoerente?
> 2. C’è stato un ritardo ingiustificato o un mancato accesso alle cure?
> 3. La lesione è compatibile con un abuso o la spiegazione data è vaga, cambiante, o incompatibile con la lesione osservata? ci sono segni di trascuratezza?
> 4. Il comportamento del bambino o dei genitori è inappropriato?
> 5. Altri segnali che fanno dubitare della sicurezza del bambino/famiglia?
> Restituisci SOLO questo formato:
> 1.
> 2.
> 3.
> 4.
> 5.”

We used Openai’s gpt-3.5-turbo model, and defined the role ”Sei un esperto di medicina legale pediatrica.”. We defined the prompts in italian because the clinical data was in italian.
Here is the translation of these prompts:

> ”Read the following clinical text and fill in the checklist below.
> Answer each question only with TRUE or FALSE.
> CLINICAL TEXT: **text_case**

CHECKLIST:

1. Is the history inconsistent?

2. Was there an unjustified delay or failure in providing medical care?

3. Is the injury compatible with abuse or is the expla- nation given vague, changing, or incompatible with the observed injury? Does the child present signs of neglect?

4. Is the behavior or the interaction of the child and parent(s) inappropriate?

5. Are there other signals that make you doubt the safety of the child and/or family?

Return ONLY this format:

1.

2.

3.

4.

5.”

role: ”You are an expert in pediatric forensic medicine.”

We saved the answered checklist into a table called checklist_outputs, along with the overall result of the checklist, that is ”TRUE” if any of the questions were answered ”TRUE”, otherwise ”FALSE”.

Few-Shots Testing

Because we found a relatively high number of positives - 1841 of the 21826 cases - and we know that the doctors hadn’t classified as suspected abuse more than 17, we know that we are probably dealing with false positives.

The distribution of the positive cases is shown in figure 6.2. The cases are grouped by the answers to the checklist. The most common questionnaire

result between the cases classified as positive is:

”CHECKLIST:
”1. → FALSE
”2. → FALSE
”3. → TRUE
”4. → FALSE
”5. → TRUE

Closely followed by:

”CHECKLIST:
”1. → FALSE
”2. → FALSE
”3. → FALSE
”4. → FALSE
”5. → TRUE

This last result is very surprising because it means that the model answered ’TRUE’ to the question: *Are there other signals that make you doubt the safety of the child and/or family?*. This is a rather subjective question, because it doesn’t rely on any of the physical or behavioral signs covered by the other questions. But instead it addresses a kind of unexplainable gut feeling that a seasoned doctor may have, without having any physical signs or symptoms that he can directly address. This means that in the clinical text provided, there weren’t any symptoms neither physical nor emotional, behavioral etc, that indicate possible abuse. It was an answer given by the model because of a ’feeling’. This was an answer given to more than 550 cases, that’s almost half of the total positive cases.

Since the number of this group of cases (1841) is a lot smaller than the initial number (21791), we decided to use FEW_SHOTS to train the model,

and re-classify the positive cases.

These are the few shots we defined. We took the descriptions of the cases and the compilation of the checklists from the manual testing section:

”FEW_SHOTS =

”ESEMPIO 1:

CASO CLINICO: Il primo caso riguarda un bambino con lividi e abrasioni nella parte bassa della schiena, al ginocchio, al braccio e al viso. La madre ha riferito che il bambino le ha detto che l’insegnante lo aveva picchiato.

”CHECKLIST:

”1. → FALSE

”2. → FALSE

”3. → TRUE

”4. → TRUE (resoconto diretto di violenza)

”5. → FALSE

ESEMPIO 2:

CASO CLINICO: Il sintomo principale del caso è un resoconto diretto di violenza dato dal bambino.

CHECKLIST:

1. → FALSE

2. → FALSE

3. → FALSE

4. → TRUE (resoconto diretto di violenza)

5. → FALSE

ESEMPIO 3:

CASO CLINICO: Il bambino presenta ecchimosi multiple e lesioni cutanee minori. Si osservano piccole ecchimosi all’avambraccio

destro, ai lati della schiena, al gomito sinistro, escoriazioni alla caviglia destra e altre lesioni. Il bambino ha riferito di essere stato colpito ripetutamente da due compagni. Ha mostrato avversione al ritorno a scuola.
CHECKLIST:
1. → FALSE
2. → FALSE
3. → TRUE (lesioni compatibili con abuso, in sedi atipiche, in diversi stadi di guarigione)
4. → TRUE (resoconto diretto e segni di evitamento)
5. → FALSE

ESEMPIO 4:
CASO CLINICO: Il bambino presenta un'eruzione pruriginosa tipo orticaria su viso, tronco e arti. Comparsa dopo un pomeriggio al parco.
CHECKLIST:
1. → FALSE
2. → FALSE
3. → FALSE
4. → FALSE
5. → FALSE

ESEMPIO 5:
CASO CLINICO: Il bambino è stato portato in ospedale per eczema.
CHECKLIST:
1. → FALSE
2. → FALSE
3. → FALSE

4. → FALSE

5. → FALSE””

We updated the initial prompt by adding this FEW_SHOTS variable in the following way:

”Leggi il seguente testo clinico e compila la checklist qui sotto.
Per ogni domanda rispondi solo con TRUE o FALSE.
+ FEW_SHOTS +
TESTO CLINICO: **testo_caso**
CHECKLIST:
1. La storia clinica è incoerente?
2. C’è stato un ritardo ingiustificato o un mancato accesso alle cure?
3. La lesione è compatibile con un abuso o la spiegazione data è vaga, cambiante, o incompatibile con la lesione osservata? ci sono segni di trascuratezza?
4. Il comportamento del bambino o dei genitori è inappropriato?
5. Altri segnali che fanno dubitare della sicurezza del bambino/famiglia?
Restituisci SOLO questo formato:
1.
2.
3.
4.
5.”

With this updated prompt, the model changed some of the cases previously identified as true to false.

To check the correctness of this classification, we performed the automatic testing on the manually tested cases (the 17 nap cases and 18 non nap cases

defined in the previous section 6.1), and found that in the automatic testing 6 of the 17 positive nap cases were wrongly classified as false. And all of the negative nap cases (18/18) were correctly classified as false.

6.2.2 Analysis and observations on the automatic results

After this final classification, we are left with 1160 positive values and 20666 negatives. Of these values we estimate to have:

TP (True positive): 11

TN (True negative): 20660

FP (False positive): 1149

FN (False negative): 6

The results can be better visualized in figure 6.3.

Note that this data is just an estimate because we are dealing with suspicion of possible cases, not actual confirmations, and these suspicions are also defined by the doctors and we've defined the positive cases as such because in the clinical data it was explicitly reported the word 'NAP' which may have been implicit in some other cases thus leading us to a wrong definition of false positives. It is necessary to take into account human error and data errors.

This result indicates that this checklist should not be automatically answered by AI given the doctor's description of the clinical data, and especially not by an untrained AI. The questionnaire should be answered by the medical professionals.

6.3 Testing conclusions and observations

The automatic testing classified a 5% of negative cases as positive, and a very high 35% of positive cases as negative. Since the testing was performed using an untrained model, it was expected that it would perform relatively

poorly. Like we mentioned earlier, almost half of the false positive cases were classified this way because the model had a 'feeling that made it doubt the safety of the child or of the family', which is kind of a vague question to ask a model that may lack the context to 'understand' that we are referring to safety in regards to abuse, and may interpret a child with high fever as unsafe to return home, and means the answer of the question as 'the child should stay at the hospital', for example.

In the manual testing, we found a couple of false positives, and zero false negatives. Which is a better result than we had with the automated testing. We must keep in mind that the manual testing was not performed by medical professionals, it was performed by compiling the questionnaire faithfully trying to stay as objective as possible (with no subjective interpretation of the context or explanations).

Because of the false positives and false negatives, we must keep in mind that the questionnaire is to be used as an internal tool for the doctors.

In regards to the false positives, it is not a problem to make the doctor alert of a possible abuse symptom, but it shouldn't be taken as the only tool available, such that if there is a true isolated symptom then the social services shouldn't automatically be called. But it is appropriate that the doctor considers the possibility that there may be an abusive situation, and if he is not very experienced in this specific field, than he could consult with a more experienced doctor, to deal with the doubt, for example.

It is extremely important to find the correct equilibrium between flagging a case as suspicion of nap too easily and for it to have requisites that are too hard to reach, because either way the consequences are serious. Many abuse cases start in a way that is not easy to recognize, and what could be seen as a too easy flag could come to be a very early recognition. And the reverse could also be true: maybe there is a child that turns out to be very prone to having accidents and it may be traumatizing to be the center of a criminal investigation on his parents.

Overall, as was the case with the ESCAPE and SCAN tools, thousands of compiled questionnaires can little by little help train an AI model that will be able to correctly classify a case of suspected abuse as a case of actual abuse or of no abuse.

Correlations on the answers to the questions could be explored, for example if the injury is in an atypical location but it is compatible with the explanation given, then we may find that the suspicion will turn out to be debunked. But at this time, we have too little information to make that sort of assumptions.

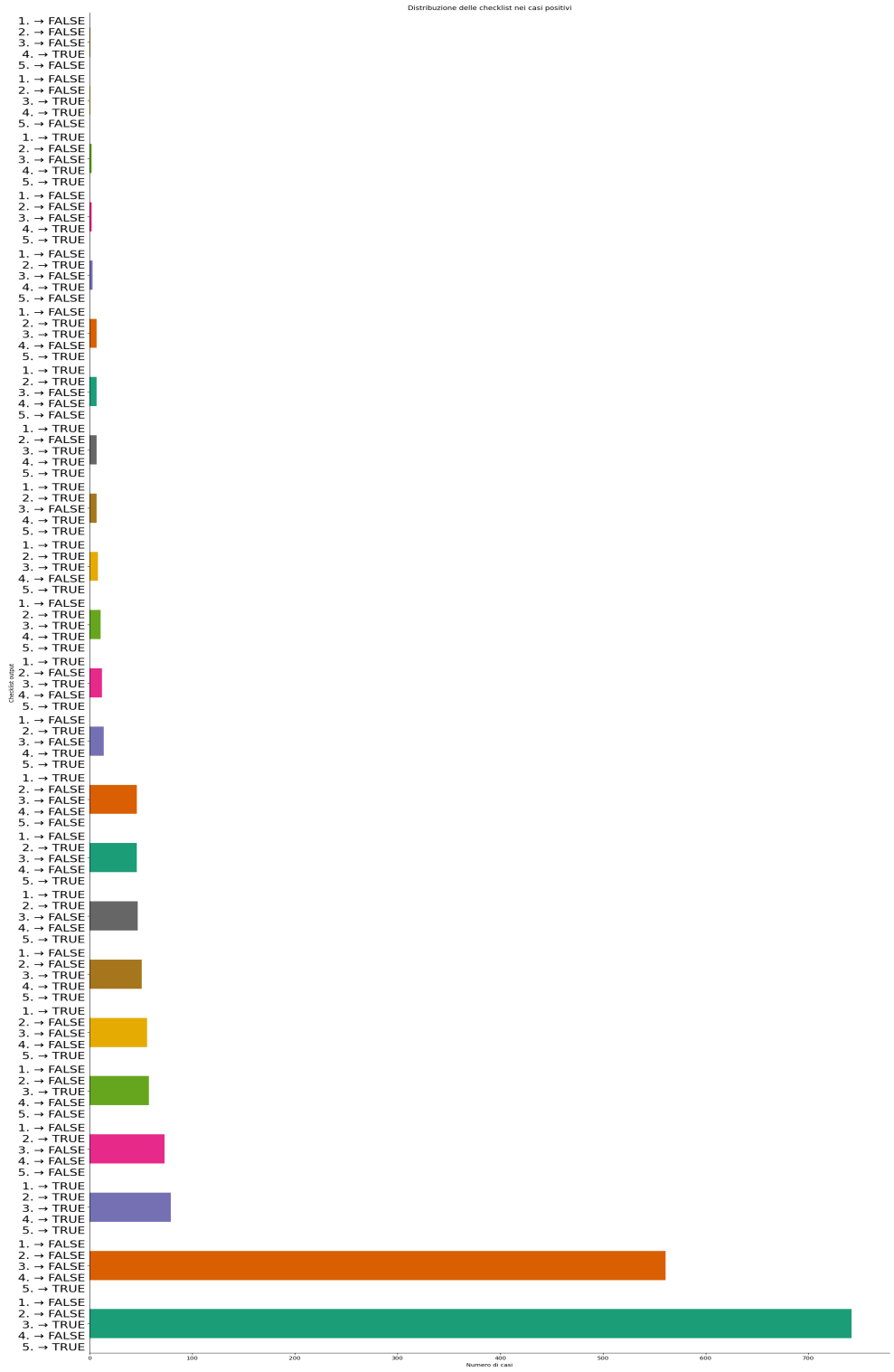

Figure 6.2: Distribution of the positive cases, grouped by the answers of the checklist.

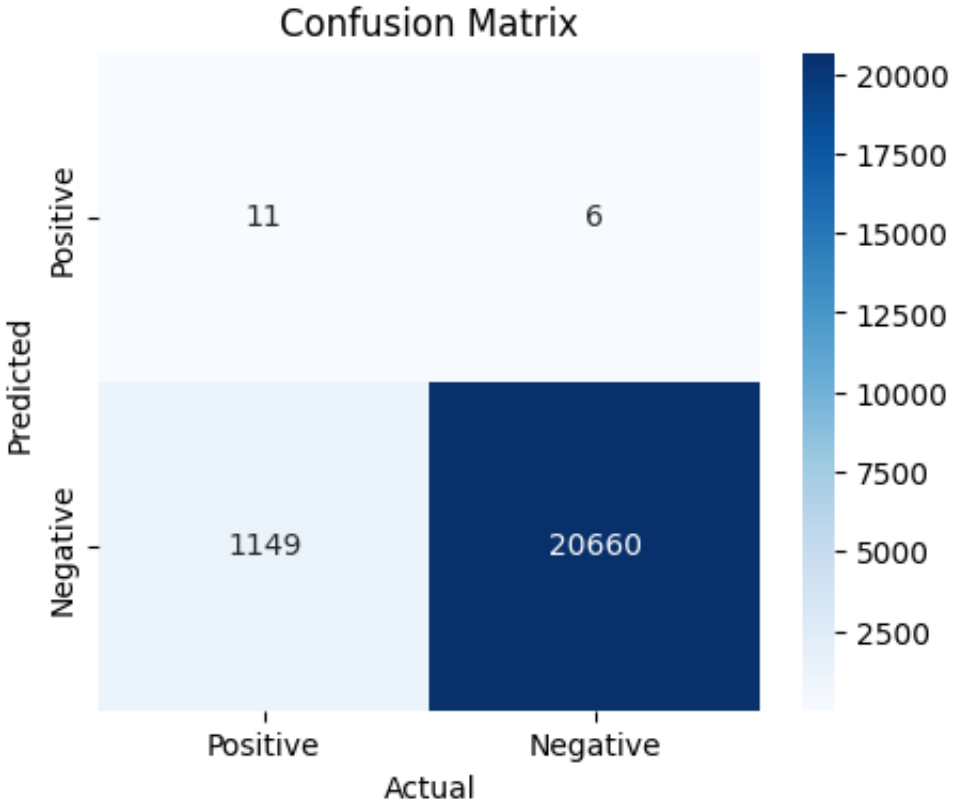

Figure 6.3: Confusion Matrix of the automatic results. The true positives are 11/17, the true negatives are 20660/20666, the false positives are 1149 and the false negatives are 6.

Chapter 7

Conclusions

This project started as a request from the Sant'Orsola's doctors for a tool that could help ED doctors identify cases of suspected abuse in children.

We were given a large dataset of medical cases and professional medical manuals that describe the symptoms that a doctor should look out for, along with the behavior the doctor should maintain while dealing with at risk patients.

Initially, we considered the idea of designing and implementing a classification model trained on the provided dataset, but because of the limitations of the data, that is the lack of numerous positive NAP cases, and the fact that the clinical data was unstructured, we decided to consider other options.

After researching existing solutions to this NAP identification problem, also in other countries, we found two very important and relevant studies: ESCAPE [16] (chapter 2.1) and SCAN [7] (chapter 2.2).

We used the provided manuals to extract the rules relevant for our problem, that is the pattern of clinical symptoms, behaviors and medical history inconsistencies that the doctors should pay attention to, in at risk patients.

After structuring and analyzing these rules, we created a checklist, and compared it to the questionnaires proposed in the ESCAPE and the SCAN instruments.

We tested the checklist both manually and automatically and obtained consistent results, that indicate that the questionnaire can be a valid and functioning tool that can help the doctors to quickly identify possible cases of child abuse.

We took into consideration during our analysis the fact that the ED doctors are often in busy situations, so the tool had to be not only effective but fast to use and we feel that we managed to create a good equilibrium of these factors when creating our 5-item checklist.

This instrument will be given to the Sant'Orsola doctors to evaluate, and hopefully it will then come into use in the Sant'Orsola's Emergency Department.

This study could be a pilot study that can grow in the future and the checklist could become an instrument of standard use in other hospitals and pediatric clinics. We hope that, if the checklist is regularly used, the answers of the questions could be stored in a structured dataset that can be later used to implement an instrument similar to SCAN, so that the future clinics may have a validated tool that can correctly identify cases of abuse from the earliest stages.

Ideally, these data could be centralized, so that if a child that changes residence enters an ED in a new city, the doctor could access the previously compiled checklists of the patient. That would help answer the question regarding the medical history of a child, and also help the doctors keep watch on seemingly innocuous symptoms like bruises in atypical area but accompanied by a plausible explanation. Because in repeated visits to the ED these symptoms could be found to be recurrent.

Overall, we are satisfied by the result of this study, and being able to create a helpful tool that can assist, not substitute, the medics.

Bibliography

[1] J. H. Abusamra, S. Ali, K. W. Elhussien, A. M. Mirghani, A. A. Ahmed, and A. M. Ibrahim. Ethical and practical considerations of artificial intelligence in pediatric medicine: a systematic review. *Cureus*, 2025. URL: https://www.cureus.com/articles/342770-ethical-and-practical-considerations-of-artificial-intelligence-in-pediatric-medicine-a-systematic-review#!/. Accessed June 2025.

[2] AEQUITAS Consortium. Aequitas framework. https://aequitas-home.readthedocs.io/en/latest/fair-by-design.html, 2023. Accessed June 2025.

[3] AEQUITAS Consortium. Aequitas methodology: fairness-aware ai by design. https://aequitas-home.readthedocs.io/en/latest/methodology.html, 2023. Accessed June 2025.

[4] M. De-Arteaga, R. Fogliato, and A. Chouldechova. Case study: algorithmic risk assessments in the hands of humans. *arXiv preprint arXiv:2002.08035*, 2020. URL: https://arxiv.org/abs/2002.08035.

[5] Autorità Garante per l'Infanzia e l'Adolescenza. Maltrattamenti su bambini e adolescenti: aumentati in italia del 58% in cinque anni. https://www.garanteinfanzia.org/maltrattamenti-aumentati-58, 2025. Accessed June 2025.

[6] V. Eubanks. Excerpt from automating inequality. *WIRED*, 2018. Accessed June 2025.

[7] F. Hoedeman, P. Puiman, E. van den Heuvel, M. Affourtit, R. Bakx, M. Langendam, E. van de Putte, I. Russel-Kampschoer, M. Schouten, A. Teeuw, H. de Koning, and H. Moll. A validated screening instrument for child abuse and neglect (scan) at the emergency department. *European Journal of Pediatrics*, 182(1):79–87, 2023. DOI: 10.1007/s00431-022-04635-0.

[8] K. Kawakami, P. Emami, S. Ghosh, Z. Lin, D. Kluttz, and M. Srivastava. Human–ai collaboration in child welfare screening: the role of human discretion. *arXiv preprint arXiv:2204.02310*, 2022. URL: https://arxiv.org/abs/2204.02310.

[9] R. Landau, A. Singh, and B. Thomas. Using the area deprivation index to reduce disparities in child abuse and neglect detection using ai. *Journal of Child and Adolescent Social Work*, 2024. DOI: 10.1007/s42448-025-00223-5. Early Access.

[10] F. Lupariello, F. Perrelli, A. Sirignano, G. Ricci, M. Ceccanti, and F. Cipriani. Artificial intelligence and child abuse and neglect: a systematic review. *Children*, 10(10):1659, 2023. DOI: 10.3390/children10101659.

[11] A. News. Us probes use of ai to screen pittsburgh families for child neglect. https://apnews.com/article/4f61f45bfc3245fd2556e886c2da988b, 2023. Accessed June 2025.

[12] V. Ntinopoulos, H. R. C. Biefer, I. Tudorache, N. Papadopoulos, D. Odavic, P. Risteski, A. Haeussler, and O. Dzemali. Large language models for data extraction from unstructured and semi-structured electronic health records: a multiple model performance evaluation. *BMJ Health & Care Informatics*, 32(1):e101139, 2025.

[13] O. of Justice Programs. Accuracy of a screening instrument to identify potential child abuse in emergency departments. https://www.ojp.gov/ncjrs/virtual-library/abstracts/accuracy-screening-

instrument-identify-potential-child-abuse, 2014. Accessed June 2025.

[14] C. D. of Social Services. Cwds research summary: use of ai tools in social work and child welfare services. K. Hughes, editor, October 2023. URL: https://theacademy.sdsu.edu/wp-content/uploads/2024/01/CWDS-Research-Summary_-Use-of-AI-Tools-in-Social-Work-and-Child-Welfare-Services_October-2023_.pdf?utm_source=chatgpt.com. Accessed: june 2025.

[15] P. Saleiro, B. Kuester, L. Hinkson, J. London, A. Stevens, A. Anisfeld, K. T. Rodolfa, and R. Ghani. Aequitas: a bias and fairness audit toolkit. *arXiv preprint arXiv:1811.05577*, 2018. URL: https://arxiv.org/abs/1811.05577.

[16] J. Sittig, C. Uiterwaal, K. Moons, and et al. Accuracy of a screening instrument to identify potential child abuse in emergency departments. *Archives of Disease in Childhood*, 99(Suppl 2):A18.4–A18.4, 2014. DOI: 10.1136/archdischild-2014-306237.42.

Acknowledgements

I would like to thank first and foremost my supervisor Roberta Calegari and my co-supervisor Andrea Borghesi, for helping, guiding and encouraging me throughout this process.

I would also like to thank Marcello Lanari and Monia Gennari for introducing me to this important topic. Their work and contributions made this project possible.

I have the deepest respect and gratitude for all the doctors and professionals who work in this field and dedicate their days - and themselves - to helping and protecting children.

Lastly, grazie to my family and friends for the moral support you've given me all these years.