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EVICheck: Evidence-Driven Independent Reasoning and Combined Verification Method for Fact-Checking

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Abstract

Large Language Models (LLMs) and Retrieval-Augmented Generation (RAG) have demonstrated significant potential in automated fact-checking. However, existing methods face limitations in insufficient evidence utilization and lack of explicit verification criteria. Specifically, these approaches aggregate evidence for collective reasoning without independently analyzing each piece, hindering their ability to leverage the available information thoroughly. Additionally, they rely on simple prompts or few-shot learning for verification, which makes truthfulness judgments less reliable, especially for complex claims. To address these limitations, we propose a novel method to enhance evidence utilization and introduce explicit verification criteria, named EVICheck. Our approach independently reasons each evidence piece and synthesizes the results to enable more thorough exploration and enhance interpretability. Additionally, by incorporating fine-grained truthfulness criteria, we make the model's verification process more structured and reliable, especially when handling complex claims. Experimental results on the public RAWFC dataset demonstrate that EVICheck achieves state-of-the-art performance across all evaluation metrics. Our method demonstrates strong potential in fake news verification, significantly improving the accuracy.

1 Introduction

Fact-checking involves verifying the accuracy of claims or information, often to determine whether they are true or false. Traditionally, experts manually assess claims using authoritative sources and their expertise, with platforms like PolitiFact[1] leading the way. Automated approaches, such as FEVER [Thorne *et al.*, 2018], scale the verification process using knowledge bases like Wikipedia. However, manual methods are limited by scale, and automated techniques, while scalable, struggle with complex claims and with ensuring verification accuracy without human oversight.

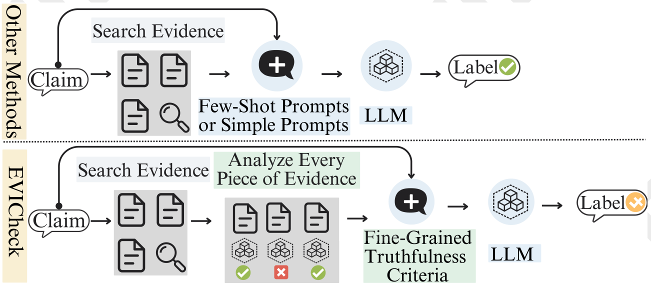

Figure 1: Comparison between EVICheck and other methods: other methods perform reasoning based on simple prompts after collecting evidence, while EVICheck independently analyzes each piece of evidence and decides based on fine-grained truthfulness criteria.

Recent advancements in Large Language Models (LLMs) and Retrieval-Augmented Generation (RAG) have improved automated fact-checking systems [Guu *et al.*, 2020; Izacard and Grave, 2021]. With strong language comprehension and efficient use of external knowledge bases, these systems offer notable advantages in tackling fact-checking tasks [Ostrowski *et al.*, 2021; Chen *et al.*, 2024; Lewis *et al.*, 2020]. However, existing methods face persistent challenges in verifying complex disinformation [Chern *et al.*, 2023; Khaliq *et al.*, 2024]. One major limitation lies in evidence utilization [Atanasova *et al.*, 2020; Kotonya and Toni, 2020]. While evidence is often collected through various approaches, most methods rely on overall validation instead of independently analyzing each piece of evidence, resulting in incomplete exploration of available information [Khaliq *et al.*, 2024; Yue *et al.*, 2024]. We term this problem Insufficient Evidence Utilization (IEU). Furthermore, many methods lack clear verification standards, often using simple prompts or

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[1] https://www.politifact.com/

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few-shot examples for credibility verification, which undermines their reliability when dealing with complex or ambiguous claims [Zhang and Gao, 2023; Yue *et al.*, 2024]. Addressing these gaps requires more effective evidence utilization and the establishment of robust verification standards.

Inspired by structured reasoning and evidence integration used by humans to address complex issues, recent research has sought to improve the reliability and transparency of automated systems [Chern *et al.*, 2023; Zamani and Bendersky, 2024]. However, many approaches struggle to integrate evidence verification and reasoning effectively, limiting their capacity to process complex information [Khaliq *et al.*, 2024; Zhang and Gao, 2023]. To overcome these challenges, we propose EVICheck, a novel method that enhances evidence-based reasoning and introduces fine-grained truthfulness criteria to improve fact-checking performance.

EVICheck performs independent reasoning for each piece of evidence, ensuring that each piece is thoroughly analyzed and utilized rather than being overshadowed by collective aggregation, as shown in Figure 1. It also introduces fine-grained truthfulness criteria, making the evaluation process more structured and reliable. We also integrate search engine APIs (e.g., SerpApi[2]) into the RAG process to ensure the system can access the most up-to-date relevant information, enhancing the model's real-time capability and accuracy. Experimental results show that EVICheck performs best on the public RAWFC dataset, particularly demonstrating superior potential compared to existing methods when handling complex, ambiguous, or controversial statements.

Our contributions can be summarized as follows:

- We propose the EVICheck method, which fully utilizes each piece of evidence by performing independent reasoning, enhancing the comprehensiveness and effectiveness of evidence utilization.
- We construct fine-grained truthfulness criteria within the framework, offering a more structured and reliable fact-checking process and improving the model's decision-making accuracy, particularly on complex statements.
- We demonstrate the superiority of EVICheck through experiments on the public RAWFC dataset, showing its significant application potential in fact-checking.

2 Related Work

Fact-Checking Based on LLMs and RAG. Large Language Models (LLMs) and Retrieval-Augmented Generation (RAG) methods are effective tools for improving fact-checking accuracy. While LLMs embed extensive knowledge through pretraining, relying on static data limits their timeliness and knowledge coverage [Izacard and Grave, 2021; Wang *et al.*, 2023]. RAG methods address this by incorporating external knowledge sources to enhance LLMs' knowledge acquisition [Borgeaud *et al.*, 2022; Wu *et al.*, 2022]. For example, LLM-Augmenter [Peng *et al.*, 2023] combines local knowledge bases with automatic feedback. However, its performance is constrained by delays in updating the knowledge base. To improve timeliness, researchers have utilized search engine APIs, such as RAGAR [Khaliq *et al.*, 2024] with the DuckDuckGo Search. However, these methods often focus on aggregating multiple pieces of evidence into a single decision-making process without independently analyzing each piece, leading to insufficient utilization of the available evidence. This limits their ability to explore and validate contributions of evidence in fact-checking tasks fully.

Evidence-Based Interpretable Fact-Checking. Evidence-based fact-checking methods verify claims by retrieving relevant evidence, typically using external knowledge sources like knowledge graphs or document fragments [Shang *et al.*, 2022; Wang and Shu, 2023; Zhao *et al.*, 2023]. With the advent of LLMs (e.g., GPT), generative methods have gained traction in providing transparent, human-like explanations. These methods combine extractive and abstractive summarization to extract key information and generate coherent, contextually connected explanations, thereby improving interpretability [Atanasova *et al.*, 2020; Kotonya and Toni, 2020]. However, most existing methods lack fine-grained truthfulness criteria to evaluate claims systematically. This absence of structured guidance limits the reliability of these methods, particularly when dealing with complex or ambiguous claims where precise decision-making is crucial.

In summary, fact-checking methods using LLMs and RAG improve accuracy and interpretability by integrating external knowledge and generating human-like explanations. However, they struggle with insufficient evidence utilization, fine-grained truthfulness analysis, and timely updates. To bridge these gaps, we propose a novel method that optimizes evidence utilization and refines verification criteria for greater accuracy and robustness in real-world applications.

3 Our EVICheck Method

Task Definition. The task is to perform automated fact-checking of claims by evaluating their truthfulness using a multi-step reasoning process. Given a claim x, the goal is to determine its validity by retrieving relevant evidence, performing reasoning, and providing a conclusion along with an explanation. This task can be formally defined as follows:

$$(\hat{y}, e) = f_{\text{validate}}(x), \tag{1}$$

where x is the input claim to be validated, $\hat{y}$ is the truthfulness judgment (True, False, or Half), and e is the corresponding explanation. The function $f_{\text{validate}}(x)$ encompasses all the steps, including question generation, evidence retrieval, reasoning, and final aggregation of results.

As shown in Figure 2, the EVICheck method has two main modules: evidence acquisition with preliminary reasoning and combined verification based on fine-grained truthfulness criteria. The first module follows a four-step loop: generating verification questions, selecting the best one, retrieving relevant information for preliminary reasoning, and generating new questions to gather additional evidence. This process ensures comprehensive evidence collection. The second module, combined verification, integrates the collected evidence and uses fine-grained truthfulness criteria for structured evaluation, enabling accurate decision-making. The algorithm of our method is shown in Algorithm 1.

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[2] https://serpapi.com/manage-api-key

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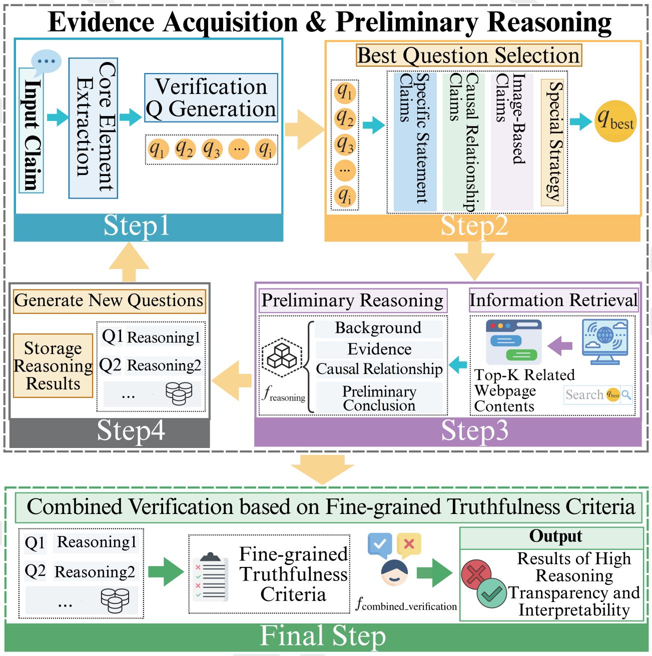

Evidence Acquisition & Preliminary Reasoning
Input Claim
Core Element Extraction
Verification Q Generation
q_1 q_2 q_3 … q_i
Step1
Best Question Selection
q_1 q_2 q_3 … q_i
Specific Statement Claims
Causal Relationship Claims
Image-Based Claims
Special Strategy
q_{best}
Step2
Generate New Questions
Storage Reasoning Results
Q1 Reasoning1
Q2 Reasoning2
…
Step4
Preliminary Reasoning
Background
Evidence
Causal Relationship
Preliminary Conclusion
$f_{reasoning}$
Information Retrieval
Top-K Related Webpage Contents
Search
Step3
Combined Verification based on Fine-grained Truthfulness Criteria
Q1 Reasoning1
Q2 Reasoning2
…
Fine-grained Truthfulness Criteria
$f_{combined\_verification}$
Output
Results of High Reasoning Transparency and Interpretability
Final Step

Figure 2: Retrieval-augmented fact verification with multi-round inference and combined verification. Evidence acquisition and preliminary reasoning use GPT and a search-engine API; after the final reasoning loop, all results are fed into the fine-tuned model using fine-grained truthfulness criteria for combined verification.

3.1 Evidence Acquisition & Preliminary Reasoning

Element Extraction and Question Generation

In this step, we aim to identify the core elements of the claim and generate verification questions from multiple aspects of the claim, as shown in Step 1 of Figure 2. For claim x, we first extract core elements, identifying key facts and verifiable information. This step ensures that the subsequent verification questions $\{q_i\}_i^m$ are focused on the aspects of the claim that require validation, preventing the process from diverging to irrelevant details. Based on these core elements, we generate targeted verification questions from multiple perspectives, ensuring alignment with the claim's content and verifiability through reliable evidence (e.g., official documents, news reports, or eyewitness accounts).

Best Question Selection

In this step, the goal is to select the most relevant validation question from the set of generated questions for retrieval, ensuring that the question chosen aligns closely with the claim's context and is effective for fact-checking, as shown in Step 2 of Figure 2. Once validation questions are generated, the large language model f_{select} selects the most relevant question q_{best} from the set $\{q_i\}_i^m$ for retrieval. The model assigns a relevance score to each question based on predefined evaluation criteria, selecting the question with the highest score:

$$q_{\text{best}} = \arg \max_{i \in \{1,\ldots,m\}} f_{\text{select}}(q_i, x), \tag{2}$$

where arg max selects the question q_i with the highest score $f_{\text{select}}(q_i, x)$, i.e., the most relevant question to the claim x.

The rationale behind choosing the best question includes reducing noise, improving efficiency, and addressing context length limitations. By choosing the most relevant question, irrelevant or noisy queries are avoided, which enhances the accuracy of verification and reduces unnecessary API calls. This approach conserves computational resources and improves overall efficiency. Additionally, pre-selecting the best question ensures the context window stays within its limits, allowing the model to process all relevant information.

Furthermore, in practice, we observed the following deficiencies in LLMs when selecting optimal questions: First, in causal relationship claims, the models tend to focus on the veracity of events A and B while neglecting the critical importance of their causal linkage. Second, when handling specific claims, the models tend to rely on official sources for evidence retrieval but struggle to obtain useful information for statements that are informally recorded or released through unofficial channels. Finally, for claims involving multimodal information such as images or videos, the models attempt to retrieve the corresponding multimodal data directly but often fail. To address these issues, we designed a series of special prompt strategies to assist the models in more accurately selecting and generating appropriate verification questions.

Information Retrieval & Preliminary Reasoning

In this step, the objective is to retrieve relevant information from external sources based on the selected question and then conduct preliminary reasoning to form an initial verification, as shown in Step 3 of Figure 2. After selecting the optimal question q_{best}, the search engine API is used to retrieve web content $\{w_i\}_{i=1}^n$ related to the selected question. Subsequently, the model $f_{\text{reasoning}}$ is used to perform integrated reasoning and summary analysis on the retrieved web content, generating a preliminary conclusion $\hat{y}_1$ and reasoning process e_1:

$$(\hat{y}_1, e_1) = f_{\text{reasoning}}(\{w_i\}_{i=1}^n,\ q_{\text{best}},\ x). \tag{3}$$

Each retrieved piece of information is analyzed individually, extracting key evidence to make a preliminary judgment. The overall preliminary reasoning result is then presented in a structured format containing the following elements:

- Background Information: Provides context to aid in understanding the background of the statement.
- Evidence: Lists key information and data extracted from each source.
- Causal Relationship: Analyzes the causal logic of the statement, assessing its rationality and consistency.
- Conclusion: Makes a preliminary verification regarding the truthfulness based on the analysis and evidence.

Loop Inference and Validation

In this step, the goal is to refine the verification process by repeatedly generating new validation questions based on the claim and the current evidence and reasoning, as shown in Step 4 of Figure 2. After the preliminary inference, new verification questions $\{{q'}_i\}_i^m$ are generated by combining the statement x with the previous inference results $\hat{y}_{i-1}$ and e_{i-1}. The generation of new questions is centered around the claim

Algorithm 1 Multi-Round Reasoning and Validation

```
Input: claim $x$, the number of iterations max_loops.
Output: Final Prediction $\hat{y}$, Explanation $e$.
$\{q_i\}_i^m \leftarrow \text{GenerateQuestions}(x)$
$q_{\text{best}} \leftarrow \text{SelectBestQuestion}(\{q_i\}_i^m, x)$
$\text{EvidenceSet} \leftarrow []$
$\text{counter} \leftarrow 0$
while counter < max_loops do
    $w \leftarrow \text{RetrieveWebContent}(q_{\text{best}})$
    $\hat{y}_{\text{current}}, e_{\text{current}} \leftarrow \text{Reasoning}(w, q_{\text{best}}, x)$
    $\text{EvidenceSet.append}(\{\hat{y}_{\text{current}}, e_{\text{current}}\})$
    $\{q'_i\}_i^m \leftarrow \text{GenFollowQ}(\hat{y}_{\text{current}}, e_{\text{current}}, x)$
    $q_{\text{best}} \leftarrow \text{SelectBestQuestion}(\{q'_i\}_i^m, x)$
    $\text{counter} \leftarrow \text{counter} + 1$
end while
$(\hat{y}, e) \leftarrow \text{CombinedValidate}(\text{EvidenceSet}, \mathcal{S})$
return $\hat{y}, e$
```

rather than being entirely dependent on the questions or reasoning results from the previous round. This strategy avoids the issue of subsequent reasoning deviating from the core due to an initial question that is off-target. Each round of question generation ensures comprehensive validation by considering both the statement's key elements and prior reasoning results.

Once the loop counter reaches `max_loops`, the loop terminates and proceeds to the next module to start the final step.

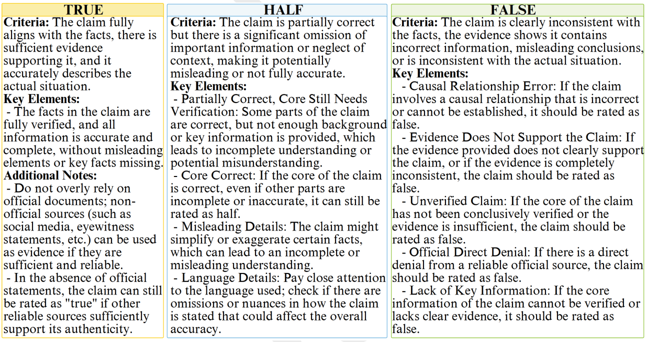
3.2 Evidence Aggregation and Combined Verification

In this step, the goal is to aggregate the evidence from multiple rounds of reasoning and validation and then combine them to make a final, accurate verification, as shown in the Final Step of Figure 2. The process begins with several rounds of reasoning, where question-reasoning result pairs $\{(\hat{y}_i, e_i)\}_{i=1}^m$, which include validation questions and their corresponding background information, evidence, causal analysis, and preliminary conclusions—are generated and iteratively refined. After multiple rounds, these evidence and preliminary judgments are aggregated and validated, guided by a set of fine-grained truthfulness criteria $\mathcal{S}$, which define evaluation rules for conclusions (True, False, Half) and provide clear guidelines for the model, as shown in Table 1. The conclusion $\hat{y}$ and explanation e are derived, ensuring both high credibility and accuracy.

To further improve the accuracy of the model's verification, we fine-tuned the model $f_{\text{combined\_verification}}$ using a supervised learning approach on the X_{train} dataset. In the fine-tuning process, we used the LLaMA-Factory framework[3] [Zheng *et al.*, 2024] along with the LoRA (Low-Rank Adaptation) method [Hu *et al.*, 2022], freezing all parameters except for the LoRA adapters. The fine-tuning was performed for three epochs. The objective is to maximize the accuracy of the final prediction by minimizing the loss function, which quantifies the difference between predicted and actual outcomes:

$$\min_{\theta} \mathbb{E}_{(x,\hat{y}_i,e_i)\sim X_{\text{train}}} \left(L(\theta, x, \{\hat{y}_i, e_i\}_{i=1}^m, \mathcal{S}) \right), \qquad (4)$$

where θ represents the model parameters, x is the input statement, $\hat{y}_i$ and e_i are the predicted conclusions and explanations from the previous reasoning rounds, X_{train} is the training dataset, and L is the loss function that quantifies the difference between the model's prediction and the ground truth. The goal is to minimize the loss, ensuring that the model's final prediction $\hat{y}$ is as accurate as possible based on the aggregated evidence and the criteria $\mathcal{S}$.



TRUE	HALF	FALSE
Criteria: The claim fully aligns with the facts, there is sufficient evidence supporting it, and it accurately describes the actual situation. **Key Elements:** - The facts in the claim are fully verified, and all information is accurate and complete, without misleading elements or key facts missing. **Additional Notes:** - Do not overly rely on official documents; non-official sources (such as social media, eyewitness statements, etc.) can be used as evidence if they are sufficient and reliable. - In the absence of official statements, the claim can still be rated as "true" if other reliable sources sufficiently support its authenticity.	**Criteria:** The claim is partially correct but there is a significant omission of important information or neglect of context, making it potentially misleading or not fully accurate. **Key Elements:** - Partially Correct, Core Still Needs Verification: Some parts of the claim are correct, but not enough background or key information is provided, which leads to incomplete understanding or potential misunderstanding. - Core Correct: If the core of the claim is correct, even if other parts are incomplete or inaccurate, it can still be rated as half. - Misleading Details: The claim might simplify or exaggerate certain facts, which can lead to an incomplete or misleading understanding. - Language Details: Pay close attention to the language used; check if there are omissions or nuances in how the claim is stated that could affect the overall accuracy.	**Criteria:** The claim is clearly inconsistent with the facts, the evidence shows it contains incorrect information, misleading conclusions, or is inconsistent with the actual situation. **Key Elements:** - Causal Relationship Error: If the claim involves a causal relationship that is incorrect or cannot be established, it should be rated as false. - Evidence Does Not Support the Claim: If the evidence provided does not clearly support the claim, or if the evidence is completely inconsistent, the claim should be rated as false. - Unverified Claim: If the core of the claim has not been conclusively verified or the evidence is insufficient, the claim should be rated as false. - Official Direct Denial: If there is a direct denial from a reliable official source, the claim should be rated as false. - Lack of Key Information: If the core information of the claim cannot be verified or lacks clear evidence, it should be rated as false.

Table 1: Fine-grained truthfulness criteria.

	false	half	true	total
train	514	537	561	1612
test	66	67	67	200
validation	66	67	67	200

Table 2: RAWFC data statistics.

4 Experimental Setting

Dataset. We adopt the English fake news dataset RAWFC [Yang *et al.*, 2022] for experiments. The dataset was created by collecting claims from Snopes[4] and retrieving the relevant raw reports. It includes three categories of labels: True, False, and Half, with each data entry provided with a manually annotated "golden label" explanation. The data distribution is shown in Table 2.

Experimental Details. The experiments were conducted using three different models: GPT-3.5, GPT-4, and the Llama-3-8B-Instruct model[5]. To make more accurate verification we fine-tuned Llama-3-8B-Instruct model as $f_{\text{combined\_verification}}$. SerpApi was used as the search API in the experiment. To reduce computational overhead was conducted based on $M = 5$ validation questions and performing $N = 2$ rounds of loop inference. Although we found that increasing the number of training rounds and questions could lead to improved results, further details are shown in Figure 5.

Baseline. We employ two categories of baselines:

- **Supervised methods**
    1) GenFE [Atanasova *et al.*, 2020]: multi-task explanation generation.
    2) SentHAN [Ma *et al.*, 2019]: hierarchical attention over sentence-level evidence.

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[3] https://github.com/hiyouga/LLaMA-Factory/tree/main

[4] https://www.snopes.com/

[5] https://huggingface.co/meta-llama/Meta-Llama-3-8B-Instruct

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3) SBERT [Kotonya and Toni, 2020]: interpretable fact-checking for public health claims.
4) CofCED [Yang *et al.*, 2022]: cascading evidence distillation for report-based detection.

- **LLM-based methods (GPT-3.5)**
  1) CoT [Wei *et al.*, 2022]: chain-of-thought prompting for complex reasoning.
  2) Standard Prompt [Brown *et al.*, 2020]: few-shot GPT-3 prompting.
  3) Hiss [Zhang and Gao, 2023]: hierarchical hinting for statement breakdown.
  4) RAFTS [Yue *et al.*, 2024]: retrieve-and-compare using LLM synthesis.

Evaluation Metrics. To comprehensively evaluate the model's performance, three evaluation metrics were used: Macro-average Precision (P), Recall (R), and F1-score. In addition to the metrics above, we used the confusion matrix to analyze further the model's performance in the three-class classification task. The matrix displays the relationship between true labels and predicted labels, helping identify misclassification patterns. By analyzing it, we gain insights into the model's performance, particularly in recognizing categories with significant misclassification issues, guiding future optimizations, as shown in Figure 3.

5 Experimental Results

This section presents the experimental results of the proposed method, starting with an evaluation of overall performance, including comparisons with existing approaches. Ablation experiments assess the impact of individual components on performance, while manual evaluation confirms the method's practical effectiveness. Finally, a detailed analysis of the validation process and a typical case is provided.

5.1 Performance Outcome

We conducted experiments separately using GPT-3.5 and GPT-4, and then replaced the $f_{\text{combined\_verification}}$ model with the fine-tuned Llama-3-8B-Instruct model for further experimentation. The experimental results of our method, comparing them with the current SOTA results, are shown in Table 3.

The experimental results demonstrate that under the conditions of using GPT-3.5 and fine-tuned Llama 3, our approach outperformed traditional SOTA methods across all evaluation metrics. When using GPT-4 and fine-tuned Llama 3, compared to traditional SOTA methods, our method improved accuracy by 3.5%, precision by approximately 8.6%, and F1 score by about 6.0%. These results indicate a significant improvement in the accuracy and reliability of verification in the fact-checking task. The observed performance improvements can be attributed to several key innovations in our approach. First, we incorporated a preliminary reasoning step after each information retrieval, ensuring that every piece of evidence is fully utilized. Second, we introduced a set of fine-grained truthfulness criteria to guide the model in making final verification, which enhanced its performance in determining the veracity of statements. Finally, we fine-tuned the Llama 3 model specifically to perform better in fact-checking tasks, optimizing its ability to discern factual accuracy. Together, these innovations contributed to the significant performance gains observed in our experiments.

We analyzed the biases of GPT-4 and the fine-tuned Llama 3 model during verification (Figure 3). We found that GPT-4 exhibited a negative bias, such as a higher occurrence of *False* judgments and a tendency to classify *Half* claims as *False*, reflecting GPT-4's cautious bias, which influenced the model's performance. In contrast, the fine-tuned Llama 3 model displayed a more balanced bias, particularly improving accuracy when judging *Half* and *True* statements. These observations suggest that through fine-tuning, the Llama 3 model can better adapt to multidimensional verification tasks when handling complex statements, thereby enhancing the stability and reliability of the inference process.

Model	**P**	**R**	**F1↑**
Supervised Approaches			
GenFE	0.443	0.448	0.445
SentHAN	0.457	0.455	0.456
SBERT	0.511	0.460	0.484
CofCED	0.530	0.510	0.520
Methods with GPT-3.5			
CoT	0.424	0.466	0.444
Standard Prompt	0.485	0.485	0.485
Hiss	0.534	0.544	0.539
RAFTS	0.628	0.526	0.573
Ours			
EVICheck (w/ GPT-3.5)	0.577	0.580	0.579
EVICheck (w/ GPT-3.5 + Llama $3_{\text{fine-tuned}}$)	0.630	0.615	0.619
EVICheck (w/ GPT-4)	0.645	0.600	0.584
EVICheck (w/ GPT-4 + Llama $3_{\text{fine-tuned}}$)	**0.663**	**0.630**	**0.633**

Table 3: Experimental results of claim verification. Supervised results are from [Yang *et al.*, 2022]; Standard Prompt and CoT results are from [Zhang and Gao, 2023]. Llama $3_{\text{fine-tuned}}$ denotes the fine-tuned Llama-3-8B-Instruct model.

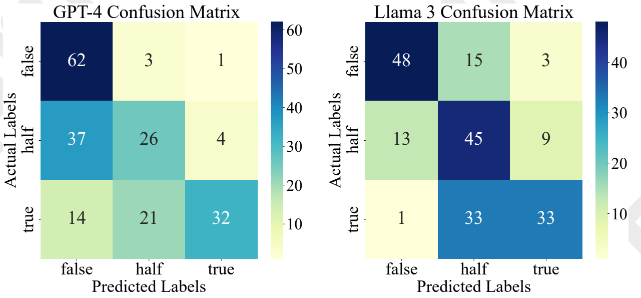

Figure 3: Confusion matrix heatmap. Left: GPT-4. Right: the fine-tuned Llama-3-8B-Instruct model.

5.2 Ablation Study

An ablation study was conducted to assess the impact of different configurations on EVICheck, as shown in Figure 4.

Effect of Model Fine-Tuning. We first evaluated the effect of fine-tuning on EVICheck. Fine-tuning the Llama 3 model using X_{train} improved final prediction accuracy by 3.47% compared to the untuned model, highlighting fine-tuning's key role in enhancing performance.

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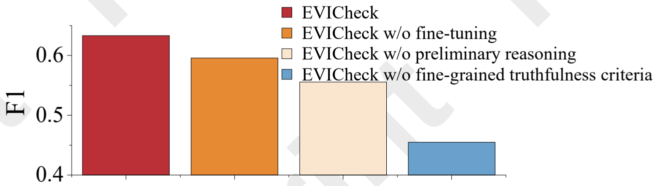

Figure 4: Experimental results of ablation study.

Effect of Preliminary Reasoning. In the original setup, the model performed preliminary reasoning—generating background, extracting evidence, analyzing causal relationships, and concluding—before combining and validating the results at the final verification node. Without preliminary reasoning, the model only gathered evidence, leading to a 7.77% performance drop. This performance drop highlights the preliminary reasoning's key role in integrating multi-round inference and improving accuracy.

Effect of Fine-Grained Truthfulness Criteria. We tested the influence of fine-grained truthfulness criteria. Removing these, along with preliminary reasoning, led to poor performance. However, incorporating our fine-grained prompt words boosted EVICheck performance by 10.08%, showing that detailed criteria significantly enhance the model's ability to perform accurate verification.

5.3 Optimal Solution for the Number of Loop Rounds and Verification Questions

To explore the optimal solution for the number of loops and verification questions, we randomly selected 12 samples (4 from each category). A total score of 12 points was assigned, with 1 point awarded for correct answers, 0 points for incorrect answers, and a 0.3-point deduction for significant errors (such as *true-false* or *false-true* discrepancies). The final score rate was computed as the ratio of the obtained score to the total score.

Number of Loop Rounds. As shown in Figure 5 (left), the number of loops was increased while fixing 2 validation questions per round. It was observed that the score rate increased with the number of loops. However, each additional loop also reduced the inference speed by 50% and increased the API call error rate. Therefore, considering both performance and efficiency, we set the number of loops to 2.

Number of Verification Questions. As shown in Figure 5 (right), the impact of varying the number of validation questions on model accuracy. With the number of loops fixed at 2, an inverted U-shaped curve in accuracy was observed. Specifically, the score rate was highest when 6 questions were posed. However, as the number of questions increased, the score rate decreased after reaching its peak. Notably, when only 1 question was asked, the score remained relatively high. We conducted a deeper analysis. Specifically, we analyzed performance for Half, True, and False declarations across different question numbers:

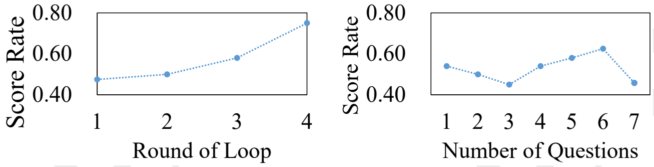

Figure 5: Left: Performance with loop rounds. Right: Performance with the number of verification questions.

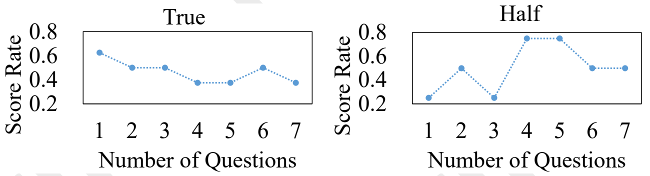

Figure 6: Left: Performance of data labeled as True. Right: Performance of data labeled as Half.

a) True: As shown in Figure 6 (left), the score for *True* decreased as the number of questions increased. With only 1 question, queries were broad, making counterevidence harder to find, leading to more *True* classifications. With more questions, the queries became more specific, reducing the number of *True* classifications.

b) Half: As shown in Figure 6 (right), the score for *Half* statements followed by an inverted U-shape. More questions made the queries more specific, helping the model assess complex statements better. However, too many questions introduced noise, reducing accuracy.

c) False: Accuracy for *False* statements remained at 100%, demonstrating the model's robustness in identifying false statements.

Additionally, fluctuations in experimental results may be influenced by data size, and future studies with larger sample sizes could further validate these conclusions.

5.4 Human Evaluation

To evaluate the performance of EVICheck in generating judgments and explanations, three experts in NLP and public opinion analysis manually reviewed the results. Each expert rated the judgments and explanations on a scale from 1 (poor) to 5 (good) based on predefined criteria.

Twelve data points were randomly selected, and two types of explanations were compared: those from the RAWFC dataset and those generated by EVICheck. Experts rated both based on the following criteria:

- **Coverage:** Whether the explanation covers the key information needed for judgment verification.
- **Readability:** Whether the language of the explanation is concise and well-structured.
- **Accuracy:** Whether the explanation accurately reflects the data or facts and whether the reasoning is correct.
- **Conciseness:** Whether the explanation is succinct and contains only necessary information.
- **Credibility:** Whether the explanation is reasonable and convincing.

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	RAWFC	EVICheck
Coverage	3.41	**4.16**
Readability	3.82	**4.34**
Accuracy	4.25	**4.30**
Conciseness	**4.11**	3.56
Credibility	3.87	**4.23**

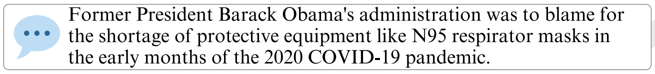
Table 4: Evaluation results of RAWFC and EVICheck methods across different criteria.

To reduce bias, we randomized the order of the explanations in each questionnaire. Expert ratings were then summarized, and the comparison of scores for each data point across criteria is shown in Table 4.

The results showed that EVICheck received a lower score in *Conciseness*, as manual explanations tend to be more concise. EVICheck includes reasoning steps for each loop, providing transparency but adding unnecessary details.

5.5 Case Study

This case study demonstrates our method's application in verification tasks. The target claim is shown in Figure 7.

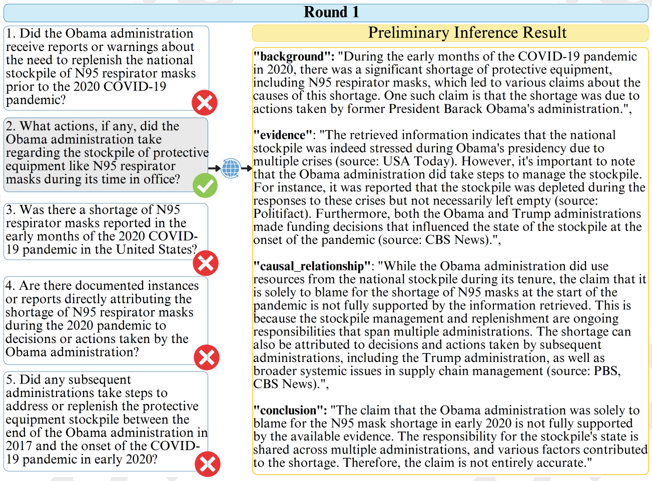


Former President Barack Obama's administration was to blame for the shortage of protective equipment like N95 respirator masks in the early months of the 2020 COVID-19 pandemic.

Figure 7: The claim to be verified.

The First-Round Verification Questions. Figure 8 shows five generated questions, with the most relevant selected for web retrieval. GPT-4 then performs preliminary inference using the retrieved information.

The Second-Round Verification Questions. As shown in Figure 9, five questions are posed based on the claim and the optimal question from the first round. The most relevant question is selected for web retrieval, and GPT-4 provides further inferences and answers.



Round 1

1. Did the Obama administration receive reports or warnings about the need to replenish the national stockpile of N95 respirator masks prior to the 2020 COVID-19 pandemic? ✗
2. What actions, if any, did the Obama administration take regarding the stockpile of protective equipment like N95 respirator masks during its time in office? ✓
3. Was there a shortage of N95 respirator masks reported in the early months of the 2020 COVID-19 pandemic in the United States? ✗
4. Are there documented instances or reports directly attributing the shortage of N95 respirator masks during the 2020 pandemic to decisions or actions taken by the Obama administration? ✗
5. Did any subsequent administrations take steps to address or replenish the protective equipment stockpile between the end of the Obama administration in 2017 and the onset of the COVID-19 pandemic in early 2020? ✗

Preliminary Inference Result

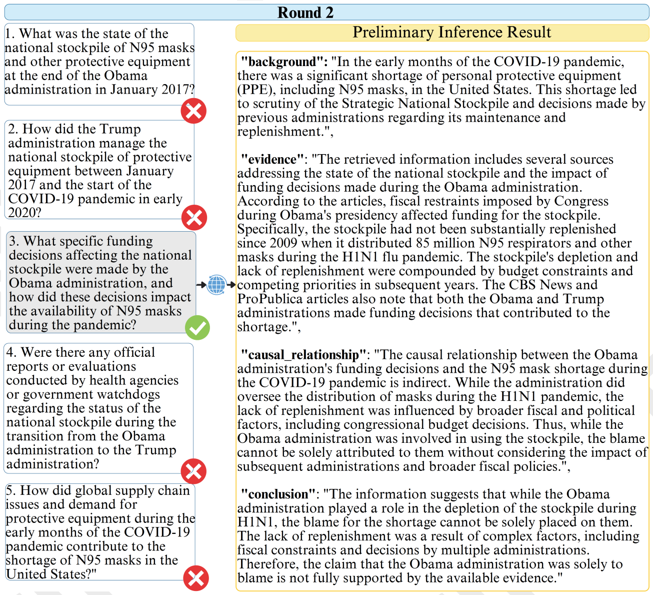
"background": "During the early months of the COVID-19 pandemic in 2020, there was a significant shortage of protective equipment, including N95 respirator masks, which led to various claims about the causes of this shortage. One such claim is that the shortage was due to actions taken by former President Barack Obama's administration.",

"evidence": "The retrieved information indicates that the national stockpile was indeed stressed during Obama's presidency due to multiple crises (source: USA Today). However, it's important to note that the Obama administration did take steps to manage the stockpile. For instance, it was reported that the stockpile was depleted during the responses to these crises but not necessarily left empty (source: Politifact). Furthermore, both the Obama and Trump administrations made funding decisions that influenced the state of the stockpile at the onset of the pandemic (source: CBS News).",

"causal_relationship": "While the Obama administration did use resources from the national stockpile during its tenure, the claim that it is solely to blame for the shortage of N95 masks at the start of the pandemic is not fully supported by the information retrieved. This is because the stockpile management and replenishment are ongoing responsibilities that span multiple administrations. The shortage can also be attributed to decisions and actions taken by subsequent administrations, including the Trump administration, as well as broader systemic issues in supply chain management (source: PBS, CBS News).",

"conclusion": "The claim that the Obama administration was solely to blame for the N95 mask shortage in early 2020 is not fully supported by the available evidence. The responsibility for the stockpile's state is shared across multiple administrations, and various factors contributed to the shortage. Therefore, the claim is not entirely accurate."

Figure 8: First-round verification questions and initial reasoning.



Round 2

1. What was the state of the national stockpile of N95 masks and other protective equipment at the end of the Obama administration in January 2017? ✗
2. How did the Trump administration manage the national stockpile of protective equipment between January 2017 and the start of the COVID-19 pandemic in early 2020? ✗
3. What specific funding decisions affecting the national stockpile were made by the Obama administration, and how did these decisions impact the availability of N95 masks during the pandemic? ✓
4. Were there any official reports or evaluations conducted by health agencies or government watchdogs regarding the status of the national stockpile during the transition from the Obama administration to the Trump administration? ✗
5. How did global supply chain issues and demand for protective equipment during the early months of the COVID-19 pandemic contribute to the shortage of N95 masks in the United States?" ✗

Preliminary Inference Result

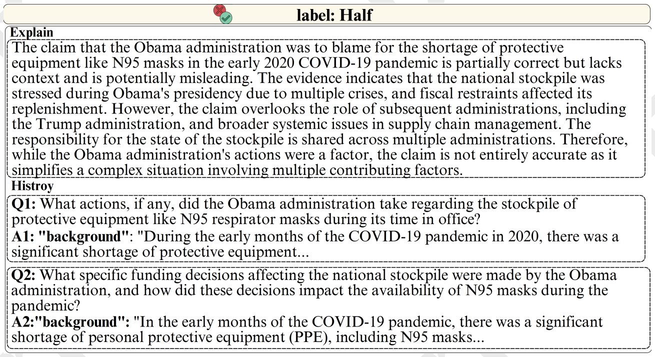
"background": "In the early months of the COVID-19 pandemic, there was a significant shortage of personal protective equipment (PPE), including N95 masks, in the United States. This shortage led to scrutiny of the Strategic National Stockpile and decisions made by previous administrations regarding its maintenance and replenishment.",

"evidence": "The retrieved information includes several sources addressing the state of the national stockpile and the impact of funding decisions made during the Obama administration. According to the articles, fiscal restraints imposed by Congress during Obama's presidency affected funding for the stockpile. Specifically, the stockpile had not been substantially replenished since 2009 when it distributed 85 million N95 respirators and other masks during the H1N1 flu pandemic. The stockpile's depletion and lack of replenishment were compounded by budget constraints and competing priorities in subsequent years. The CBS News and ProPublica articles also note that both the Obama and Trump administrations made funding decisions that contributed to the shortage.",

"causal_relationship": "The causal relationship between the Obama administration's funding decisions and the N95 mask shortage during the COVID-19 pandemic is indirect. While the administration did oversee the distribution of masks during the H1N1 pandemic, the lack of replenishment was influenced by broader fiscal and political factors, including congressional budget decisions. Thus, while the Obama administration was involved in using the stockpile, the blame cannot be solely attributed to them without considering the impact of subsequent administrations and broader fiscal policies.",

"conclusion": "The information suggests that while the Obama administration played a role in the depletion of the stockpile during H1N1, the blame for the shortage cannot be solely placed on them. The lack of replenishment was a result of complex factors, including fiscal constraints and decisions by multiple administrations. Therefore, the claim that the Obama administration was solely to blame is not fully supported by the available evidence."

Figure 9: Second-round iterative questioning and refined reasoning.



label: Half

Explain

The claim that the Obama administration was to blame for the shortage of protective equipment like N95 masks in the early 2020 COVID-19 pandemic is partially correct but lacks context and is potentially misleading. The evidence indicates that the national stockpile was stressed during Obama's presidency due to multiple crises, and fiscal restraints affected its replenishment. However, the claim overlooks the role of subsequent administrations, including the Trump administration, and broader systemic issues in supply chain management. The responsibility for the state of the stockpile is shared across multiple administrations. Therefore, while the Obama administration's actions were a factor, the claim is not entirely accurate as it simplifies a complex situation involving multiple contributing factors.

Histroy

Q1: What actions, if any, did the Obama administration take regarding the stockpile of protective equipment like N95 respirator masks during its time in office?
A1: "background": "During the early months of the COVID-19 pandemic in 2020, there was a significant shortage of protective equipment...

Q2: What specific funding decisions affecting the national stockpile were made by the Obama administration, and how did these decisions impact the availability of N95 masks during the pandemic?
A2:"background": "In the early months of the COVID-19 pandemic, there was a significant shortage of personal protective equipment (PPE), including N95 masks...

Figure 10: Final judgment based on combined verification and fine-grained truthfulness criteria.

Combined Verification and Final Judgment. Figure 10 compiles the preliminary inferences from both rounds and their evidence, then applies combined verification to make the final judgment based on fine-grained truthfulness criteria.

6 Conclusion

In this paper, we propose EVICheck, a method that enhances automated fact-checking by addressing the limitations of insufficient evidence utilization and the lack of clear verification standards. EVICheck analyzes each piece of evidence independently, conducts detailed reasoning, integrates the results, and applies fine-grained truthfulness criteria to improve reliability. Experiments on the RAWFC dataset show that EVICheck outperforms existing approaches, demonstrating its potential. Nevertheless, it still struggles with informal social-media statements and multimodal claims. Future work will integrate additional social-media APIs and strengthen multimodal reasoning. In conclusion, EVICheck offers an innovative, practical solution for combating fake news.

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