# ACCURACY OF PECARN DECISION RULE IN MINOR BLUNT HEAD TRAUMA IN PEDIATRIC EMERGENCY DEPARTMENT: A META-ANALYSIS

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## Abstract

Background: Pediatric Emergency Care Applied Research Network (PECARN) is a useful Clinical Decision Support Tool (CDST) to identify traumatic brain injuries and reduce the use of head CT scans among pediatric patients. The present Meta-analysis aims to evaluate the diagnostic accuracy of the PECARN rule from 2009 to 2020 in children with a very low risk of blunt head trauma. Methods: A detailed search was conducted from the databases of Medline (via PubMed), Cinahl (via Ebsco), Scopus, Web of Sciences, from 2009 till the end of December 2020 using the keywords like decrease use of CT scan, blunt head trauma (BHT) combined with accuracy, Pediatric Emergency Care Applied Research Network (PECARN) OR Clinical Decision Support Tool (CDST). Studies showing the diagnostic accuracy of the PECARN rule in children younger than 18 years of age with minor BHT were included. Results: 13 studies were included in the present analysis. Pooled sensitivity of 0.08, (95% confidence interval of 0.074 - 0.087), pooled specificity of 0.20 ( 95% CI of 0.196 - 0.213) and diagnostic odds ratio of 0.004 (95% CI of 0.000-0.1666) was in <2 years of age. The overall sensitivity of 0.07, specificity of 0.66, and diagnostic odds ratio of 0.54 (95% CI of 0.10 -2.78) was seen in [?]2 years of age. Overall sensitivity of 0.13 (95% CI 0.12-0.14), specificity of 0.81 (95% CI 0.80-0.82) and diagnostic odds ratio of 0.79 (95% CI of 0.08 -7.71) was in 0-18 years of age. Conclusion: The present analysis indicates the PECARN decision tool as an accurate CDST in low-risk minor blunt head trauma cases in children below two years of age and can become a useful tool in reducing Head CT's scan overuse in pediatric emergency departments.

## Introduction

Head injuries in children are a common cause of emergency department visits. More than 95 % of these constitute minor head trauma (MHT), defined as Glasgow Coma Scale (GCS) score greater than or equal to 13. Among these patients, less than 10 % have traumatic brain injuries (TBI), and less than 1 % need neurosurgery[1,2]. The uncertainty about these injuries' management increases cranial CT usage in pediatric emergency departments (PEDs), increasing the risk of ionizing radiation in children. From 1996 to 2008, CT use for pediatric patients presenting to the ED with head injury increased from 10.9% to 34.0%.[3]. Unnecessary radiologic testing utilization increases costs, increases the length of stay and may cause iatrogenic cancer in 1:1500 to 1:3000 pediatric patients [4-6]. Such children's management poses a difficulty for emergency physicians to balance the need for head computed tomography (CT) scan for intracranial injury (ICI) identification on the one hand and limiting the radiation associated risks on the other. An effective Clinical Decision Support Tool (CDST) is necessary to identify traumatic brain injuries (TBI) to optimize the risk of radiation exposure. There have been eight CDSTs identified[7]for children with a mild head injury, and Pediatric Emergency Care Applied Research Network (PECARN) clinical decision rule have been one of the most effective used decision tool in reducing the use of CT in pediatric patients with minor blunt head trauma (MBHT). PECARN was first published in 2009 by Dr. Nathan Kuppermann as a clinical prediction rule for identifying children at very low risk of clinically significant traumatic brain injuries (ciTBI) and for reducing CT use because of malignancy induced by ionizing radiation[1]. The decision tool was designed separately for two age groups of children younger than 2 years old and 2 to 18 years old with a classification of low, moderate, and high-risk patients. For patients belonging to the low-risk category, the PECARN rule does not recommend a head CT. Kuppermann et al. were successful in proving the internal validity of the PECARN decision tool. Various pediatric EDs have independently or compared with other CDSTs [8-10] have conducted studies to rule out the validation of PECARN head injury guidelines in the past, and researchers showed that application of the PECARN rule could reduce up to 58.3% of unnecessary CT scans[1]. The present study is a meta-analysis of the studies from 2009 to 2020 for the PECARN decision rule's accuracy in children with a very low risk of blunt head trauma.

## Material and methods

The present meta-analysis is an extensive search conducted in Medline (via PubMed), Cinahl (via Ebsco), Scopus, Web of Sciences, from 2009 till the end of December 2020. The search was performed based on the keywords related to decrease use of CT scan, head injuries, blunt head trauma (BHT) combined with accuracy, Pediatric Emergency Care Applied Research Network (PECARN) OR Clinical Decision Support Tool (CDST). The studies analyzing the diagnostic accuracy of PECARN rule in children younger than 18 years of age presenting to the emergency departments with minor blunt head trauma were included in the present meta-analysis. The studies with patients having Glasgow Coma Scale Score (GCS) of $> 13$ were included. Those studies where PECARN rule was applied were included in the meta-analysis. The trauma patients above 18 years with a GCS $< 13$ were excluded from the present meta-analysis. Each study was categorized as patients $< 2$ yrs of age and patients $> 2$ yrs of age. **Table.1**summarizes the demographic details of the studies included from the search query of the Medline database with the considered variables.

The present study's primary focus was to assess the efficacy of PECARN decision rules in children with minor blunt head trauma. To rule out the efficacy of the PECARN rule; sensitivity, specificity**,** positive predictive value (PPV), negative predictive value (npv), and diagnostic odds ratio's were assessed with the help of true positive (TP), false positive (FP), true negative (TN), false negative (FN) values as mentioned in Table 2.

## Statistical Description

Revman 5.2 was used to analyze for diagnostic accuracy. Considerable heterogeneity was noted in the studies included. The logarithm of the event rate was used to construct the forest plot. The random-effects model was used with statistical significance at a p value less than 0.05.

## Results

The present meta-analysis included 13 studies out of 1051 studies based on the accuracy of PECARN, as shown in Figure 1. Among 13 articles, eight articles have categorized the patient sample as <2 years and [?] 2 years of age, and five studies included patients as 0-18 years of age. A total sample size of 70,362 patients was included for the analysis from all the studies. Table 1 shows Demographic characteristics of included studies summarizing the author, time, place of study, study design, the severity of the injury, mean age, gender, practitioner assessing the patient, total sample size, and sample size depending on the age group.

For patients below two years of age, sensitivity analysis showed a pooled sensitivity of 0.08 (95% confidence interval [CI] of 0.074 - 0.087) with an inconsistency of 99.6%, which was significant at $p<0.05$ (Figure 2). Pooled specificity of 0.20 ( 95% CI of 0.196 - 0.213), which was significant at $p <0.05$ (Figure 3). The positive likelihood ratio was 0.17 (95% CI of 0.030 - 0.989), the negative likelihood ratio was 45.59 (95% CI 0.000 -0.166), and diagnostic odds ratio was 0.004 (95% CI of 0.000-0.1666) with a statistically significant value of $p<0.05$. ROC curve obtained showed the inclination of the curve towards the lower right depicting good diagnostic accuracy (Figure 4)

For patients equal to or above two years of age, sensitivity analysis showed a pooled sensitivity of 0.07 with an inconsistency of 99.5%, which was statistically significant ($p<0.05$) (Figure 5). Pooled specificity of 0.66 with the inconsistency of 99.9%, which was significant at $p<0.05$, was shown in Figure 6. The positive likelihood ratio was 1.46 (95% CI of 0.067 - 31.62), the negative likelihood ratio was 1.21 (95% CI 0.95 -1.54), and the diagnostic odd ratio was 0.54 (95% CI of 0.10 -2.78) with a statistically significant value of $p<0.05$. ROC curve obtained showed the inclination of the curve towards the lower left (Figure 7).

For the age group of 0-18years, sensitivity analysis showed a pooled sensitivity of 0.13 (95% CI 0.12-0.14) with an inconsistency of 86.7%, which was significant at $p<0.05$ (Figure 8). Pooled specificity of 0.81 (95% CI 0.80-0.82) with the inconsistency of 99.7%, significant at $p<0.05$, was shown in Figure 9. The positive likelihood ratio was 1.05 (95% CI of 0.25 – 4.34), the negative likelihood ratio was 1.36 (95% CI 1.05 -1.76), and the diagnostic odd ratio was 0.79 (95% CI of 0.08 -7.71) with a statistically significant value of $p<0.05$. ROC curve obtained showed the inclination of the curve towards the lower left (Figure 10).

**Discussion**

Traumatic brain injury (TBI) is one of the commonly encountered conditions in the pediatric emergency department, with the leading cause of mortality and disability among trauma patients[20]. Nearly one-third of these cases occurred among children aged 0 to 14 years[21]. Many clinical decision support tools have been developed, over the past years, to support the diagnosis of blunt head trauma injuries among children with low risk[22,23] and to decrease the use of computed tomography (CT) in the PED[24-26] with minimizing the exposure of potentially harmful ionizing radiation among children[27]. The pediatric population is significantly more sensitive to radiation exposure because of the increased number of dividing cells into growing children and the longer lead time children develop cancer[6]. According to Khalifa etal.[28], various clinical decision support (CDS) systems have proved to enhance evidence-based clinical practice, and the PECARN rule is considered the highest quality tool compared to the other tools. The present Meta-analysis is an effort to rule out the PECARN decision tool's efficacy in children with minor blunt head trauma.

In patients below two years of age, sensitivity analysis showed a pooled sensitivity of 0.08 (95% CI of 0.074 - 0.087), which was insignificant. Pooled specificity of 0.20 (95% CI of 0.19 - 0.21), which was not significant. The positive predictive value (PPV) was 0.17 (95% CI of 0.030 - 0.989), and the negative predictive value (NPV) was 45.59 showing an insignificant result. The overall diagnostic odd ratio for patients below two years of age was 0.004 (95% CI of 0.00-0.17), which was statistically significant in depicting a good diagnostic accuracy of PECARN decision rule in patients less than two years of age with minor blunt head trauma. The patients equal or above two years of age showed a pooled sensitivity of 0.07, the specificity of 0.66, PPV of 1.46 (95% CI of 0.067 - 31.62), and NPV of 1.21 (95% CI 0.95 -1.54). The diagnostic odd ratio for patients equal or above two years of age was 0.54 (95% CI of 0.10 -2.78), which was statistically insignificant, showing no significant role of PECARN rule in patients between 2-18 years of age with minor blunt head trauma. The overall age group of 0-18years showed pooled sensitivity of 0.13 (95% CI 0.12-0.14), specificity of 0.81 (95% CI 0.80-0.82), PPV of 1.05 (95% CI of 0.25 – 4.34) and NPV of 1.36 (95% CI 1.05 -1.76). The diagnostic odd ratio of patients between 0-18 years of age was 0.79 (95% CI of 0.08 -7.71), which was statistically insignificant, indicating no specific role of PECARN rule among 0-18 age groups in patients with minor blunt head trauma.

The present Meta-analysis showed reasonable diagnosing accuracy of PECARN rule among children less than two years of age, decreasing CT's overuse in this age group, whereas there was no significant effect of PECARN rule in children over two years of age. However, Gariepy et al.[29] showed an overuse of CT for the younger group (<2 years) to be below 3% after the PECARN decision rule in mTBIs. Lyttle et al.[30] in 2012 conducted a systematic review and described the PECARN rule to have a high methodological standard and an acceptable predictive value for mTBIs similar to our study. Ahmadi et al.[31] also recommended the decision rule to be used in routine practice for children referring to mild traumatic brain injuries similar to the present analysis.

**Limitations:**

However, there was a limitation to the present study due to significant heterogeneity between included studies. Secondly, the PECARN tool might have been implemented in various places in clinical practice, but no studies reported their implementation yet. Further, awareness and training should be given for the pediatric emergency practitioners to reduce the overuse of CT among children through various clinical decision support tools in mBHTs.

## Conclusion

The present Meta-analysis is an effort to rule out the PECARN decision tool's diagnostic accuracy and support using the PECARN decision tool in minor blunt head trauma cases with low risk in children below two years of age. This clinical decision support tool for minor blunt head trauma could become an efficient tool in reducing head CT scan with time, reducing the potentially harmful effects of radiation in pediatric populations.

## Compliance with ethical standards

Acknowledgements: Not applicable

Author's contribution: MX: Concept and designed the study, XX: analyzed data; ZC: Collected the data and helped in data analysis; HX: Drafting of the manuscript

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Availability of data and materials: The data used to support the findings of this study are available from the corresponding author upon request.

Ethical approval and consent to participate: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent: It was obtained from all individual participants included in the study.

Consent for publication Not Applicable.

Competing interests: None stated.

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**FIGURE LEGENDS:**

**Figure 1: Flow chart diagram for article inclusion**

**Figure 2: Forest plot depicting sensitivity analysis for <2 years of age**

**Figure 3: Forest plot depicting specificity analysis for <2 years of age**

**Figure 4: Forest plot depicting ROC curve for <2 years of age**

**Figure 5: Forest plot depicting sensitivity analysis for [?]2 years of age**

**Figure 6: Forest plot depicting specificity analysis for [?]2 years of age**

**Figure 7: Forest plot depicting ROC curve for [?]2 years of age**

**Figure 8: Forest plot depicting sensitivity analysis for 0-18 years of age**

**Figure 9: Forest plot depicting specificity analysis for 0-18 years of age**

**Figure 10: Forest plot depicting ROC curve for 0-18 years of age**

**Figure 1: Flow chart diagram for article inclusion**

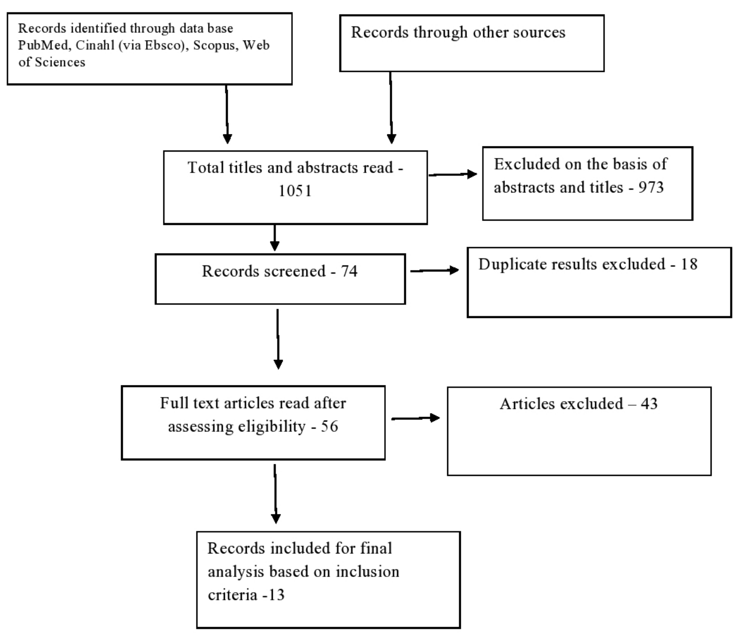


Figure 2: **Forest plot depicting sensitivity analysis for <2 years of age**

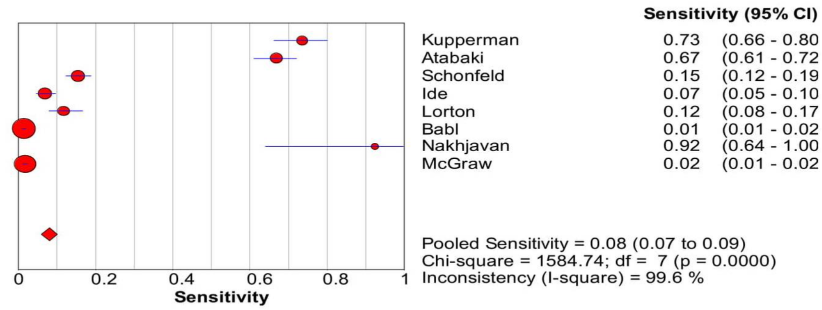



Figure 3: **Forest plot depicting specificity analysis for <2 years of age**

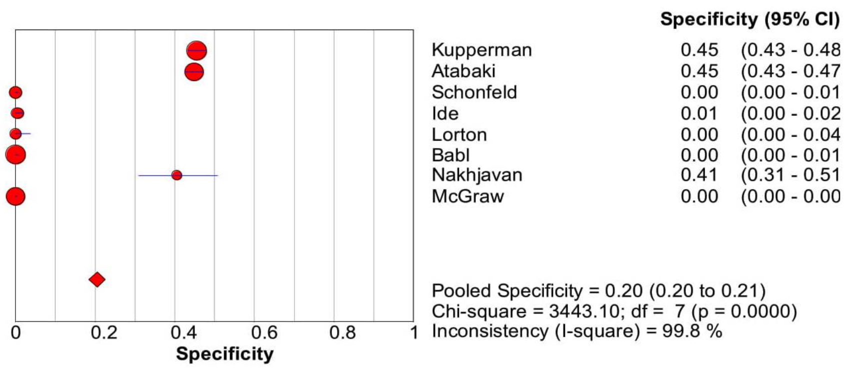


**Figure 4: Forest plot depicting ROC curve for <2 years of age**

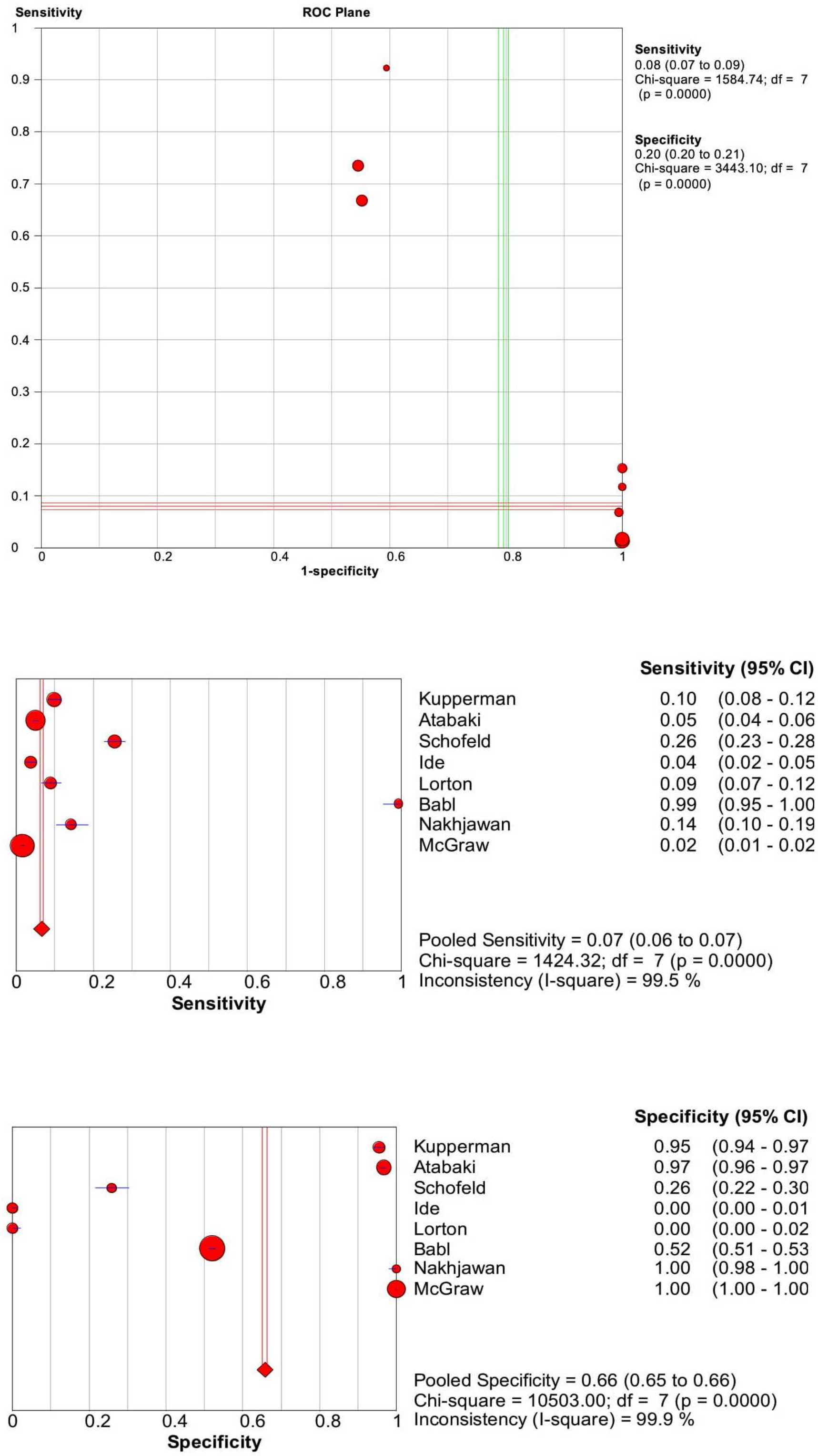


**Figure 7: Forest plot depicting ROC curve for ≥2 years of age**

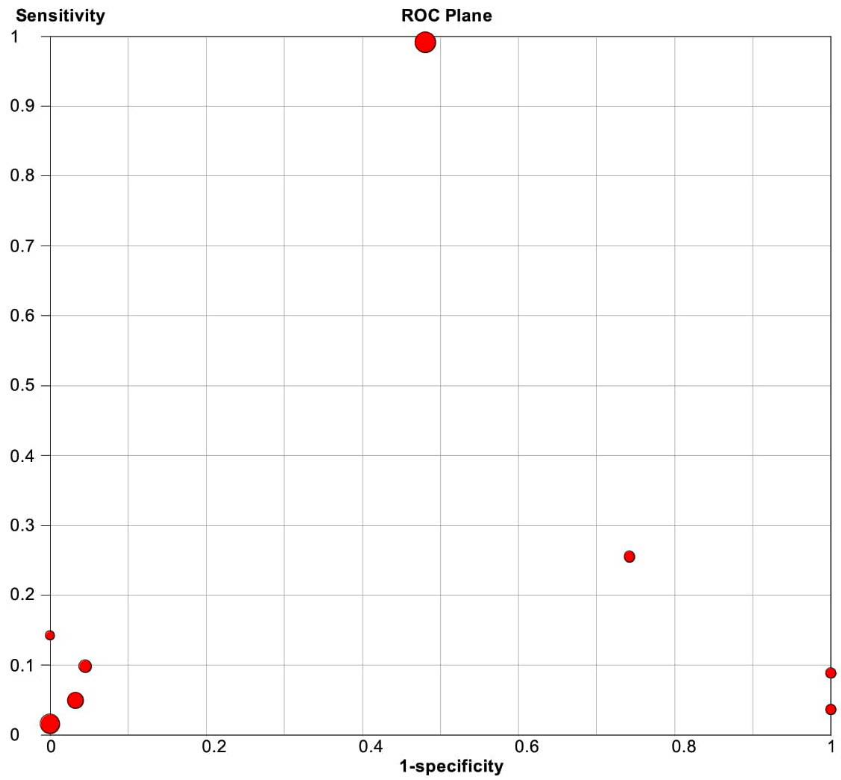



Figure 8: **Forest plot depicting sensitivity analysis for 0-18 years of age**

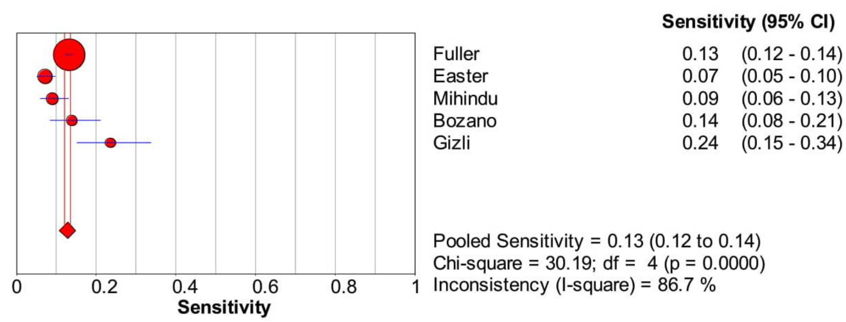


Figure 9: **Forest plot depicting specificity analysis for 0-18 years of age**

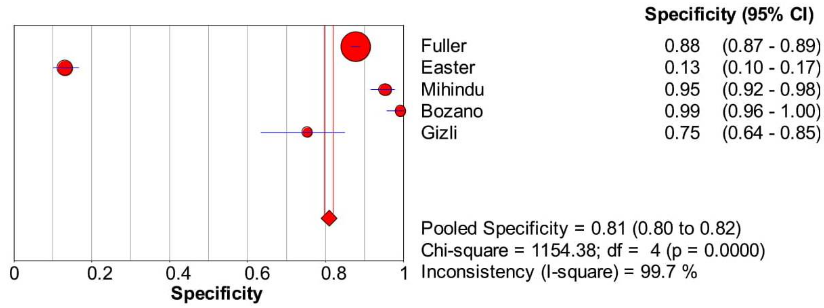
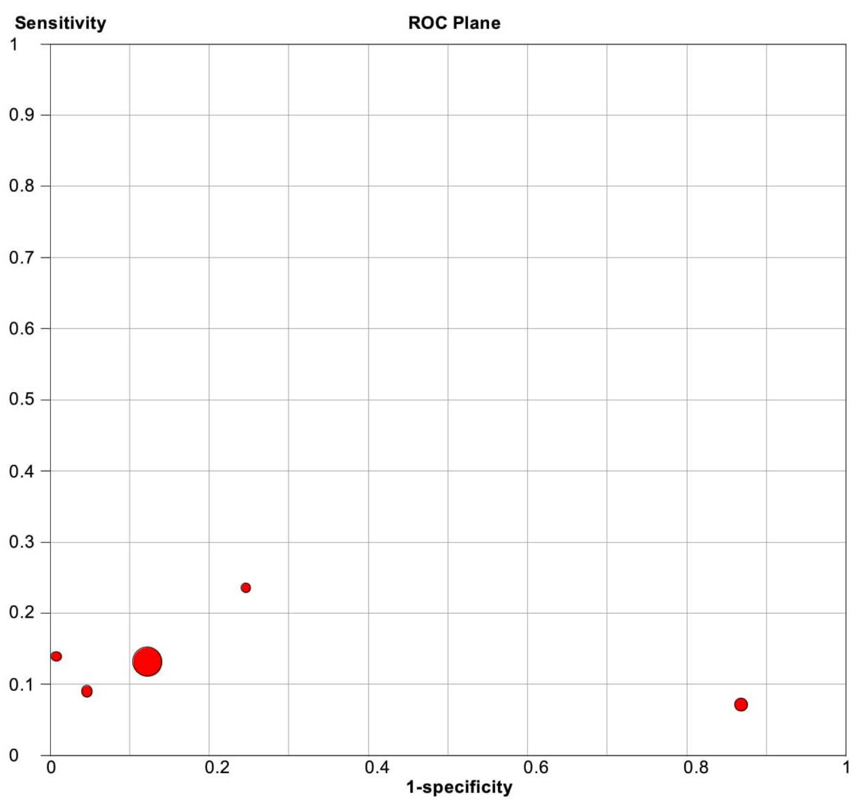



**Figure 10: Forest plot depicting ROC curve for 0-18 years of age**

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