Gender Differences in Autism Spectrum Disorder: Investigating the Role of Neonatal Jaundice

Thesis Submitted
in Partial Fulfilment of the Requirements for the
Degree of

MASTER OF TECHNOLOGY
IN
DATA SCIENCE

Submitted by

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First, I would like to thank the Almighty, who has always guided me to follow the right path of the life. My greatest thanks are to my parents who bestowed the ability and strength in me to complete this work. My thanks are addressed to my mentor **Dr. Ruchika Malhotra**, Department of Software Engineering who gave me this opportunity to work in a project under her supervision. It was her enigmatic supervision, unwavering support and expert guidance which has allowed me to complete this work in due time. I humbly take this opportunity to express my deepest gratitude to her.

Place: Delhi
Date: 2 July 2024

Md. Azizul Hakim
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CANDIDATE'S DECLARATION

I hereby declare that the work presented in this report titled "**Gender Differences in Autism Spectrum Disorder: Investigating the Role of Neonatal Jaundice**" submitted as part of the requirements for the award of the MASTER OF TECHNOLOGY degree in Software Engineering at DELHI TECHNOLOGICAL UNIVERSITY, New Delhi, is an authentic record of my own work carried out during my degree under the supervision of **Dr. Ruchika Malhotra**.

I have not submitted the work described in this report for the granting of any other degree or certificate.

Date: 2 July 2024

Md Azizul Hakim
Candidate's Signature

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CERTIFICATE

This is to confirm that Md. Azizul Hakim (2K22/DSC/19) has successfully completed the project titled "**Gender Differences in Autism Spectrum Disorder: Investigating the Role of Neonatal Jaundice**" under my supervision as part of the MASTER OF TECHNOLOGY degree in Software Engineering at DELHI TECHNOLOGICAL UNIVERSITY.

Place: Delhi
Date: 2 July 2024

Dr. Ruchika Malhotra
(Project Supervisor)
Head of Department
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ABSTRACT

Many neurodevelopmental difficulties that affect social interaction and communication are represented by autism spectrum disorder (ASD). This study delves into the gender-specific prevalence of ASD in relation to neonatal jaundice, leveraging the "Autistic Spectrum Disorder Screening Data for Toddlers" dataset based on 2018, which comprises 1,054 cases detailed across 18 attributes. The study uses ten behavioural traits (Q-Chat-10) and other measures to focus on finding gender differences in the incidence of ASD, especially in relation to neonatal jaundice. With a male-to-female ratio (MFR) of 3.479, the results show that boys with neonatal jaundice are more susceptible to ASD. The study emphasizes the significance of early diagnosis methods and proposes that tracking jaundice in addition to other possible risk factors may enable earlier ASD therapy. In spite of the insightful discoveries, the study recognizes the limitations of its dependence on secondary data and calls for larger datasets, early detection of jaundice, and other risk factors for timely diagnosis and treatment of ASD.

Keyword: Autism Spectrum Disorder (ASD), Q-Chat-10, Neonatal Jaundice, male-to-female ratio (MFR), Social Communication Questionnaire (SCQ)

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LIST OF ABBREVIATIONS

ASD	Autism Spectrum Disorder
MFR	Male-To-Female Ratio
SCQ	Social Communication Questionnaire

CHAPTER 1

Introduction

Autism Spectrum Disorder (ASD) represents a range of pervasive neurodevelopmental conditions that predominantly manifest in early childhood, impacting cognitive, social, and emotional development. Recent studies and clinical observations suggest a growing prevalence of ASD, marking it as an increasingly significant public health concern. Specifically, ASD is more commonly diagnosed in young individuals, with a noticeable escalation in diagnosis rates across various populations worldwide. [1], [2], [3], [4], [5], [6], [7] A pivotal report by the centres for Disease Control and Prevention underscores the urgency of addressing ASD, revealing that approximately one in every 68 children is diagnosed with the disorder, highlighting its widespread impact (Link) [8].

The effects of bilirubin synthesis, conjugation, enterohepatic circulation, and removal in the new-born infant combine to cause neonatal jaundice.[9] Neonatal jaundice is very common in the new-born period. [10] Previous research has examined the relationship between the likelihood of developing autism spectrum condition and new-born jaundice. While some research revealed no association [11],[12], [13] others revealed strong associations. [10], [14], [15] Recent evidence from a meta-analysis of 13 research indicates a link between ASD and new-born jaundice.[15] The relationship between neonatal jaundice and later developmental outcomes, including ASD, has been a growing area of interest within paediatric research.

The intersection of neonatal jaundice and ASD is particularly compelling. Previous research has hinted at a possible link between prolonged jaundice and neurological disorders, including ASD. However, these studies often did not fully explore how this relationship might vary between genders. Various studies showed that the gender differences is a critical factor in understanding ASD symptom [16], [17]. Given the known gender disparities in ASD where males are approximately four or three times more likely to be diagnosed than females understanding how neonatal jaundice might influence these differences is critical [18].

This research seeks to deepen the understanding of how neonatal jaundice could impact the development of ASD and whether its effects differ by gender. The study utilizes a robust dataset, which is based on ASD for Toddlers, to explore these dynamics. By focusing on gender-specific prevalence and the potential exacerbating role of neonatal jaundice, this research aims to uncover new insights that could lead to more targeted early intervention strategies, ultimately enhancing outcomes for children at risk of ASD.

CHAPTER 2

Literature Review

Several studies have investigated the association between neonatal jaundice and ASD, with conflicting findings. For instance, a retrospective cohort study by Ensiyeh Jenabi [14] found a significant association between neonatal jaundice and ASD. In this paper also highlighted that a higher risk of ASD among children with a history of neonatal jaundice. Some researcher said there is no association between neonatal jaundice and ASD [11], [13]. Despite these inconsistencies, there is emerging evidence suggesting that the relationship between neonatal jaundice and ASD may be moderated by gender and jaundice occurs more frequently among infants born preterm [19].
According to one study, family history and gender differences are genetic risk factors for autism.[20], [21]. ASD is multifaceted in its aetiology [22], [23]. The most often researched non-genetic and genetic factors linked to ASD include sociodemographic traits (e.g. advanced birth order and parent ages), physiological factors (pregnancy and delivery problems clustering, For instance, trauma, diabetes, caesarean section, and pre-eclampsia new-born jaundice, intrauterine hypoxia or birth asphyxia, low birth weight and premature birth)[24], [25].

Gender-specific differences in the prevalence of ASD have also been documented. Males are more likely to experience ASD compared to females. [8] Another study proved that Compared to females, males had more atypical visual reactions and inappropriate, stereotypical play [26], However, others looked at how well the Social Communication Questionnaire (SCQ) performed in identifying ASD in both boys and girls [27].

Mujeeb Rahman & Monica Subashini [28] uses QCHAT datasets to correctly detect autism in toddlers and found better outcomes. Also, other studies stated that predicting ASD traits based on Q-Chat-10 responses are works effectively [29], [30], [31]. Qchat-10-Score increases, the likelihood of ASD traits increases and Among individual questions (A1-A10), "A9" has the highest positive correlation (0.577) with the target variable. It suggests that the response to this question is strongly linked with ASD traits [29] Utilizing the QCHAT-10 dataset is less complex because of its ten items and binary grading system. The QCHAT-10 model can accomplish an ASD screening rapidly and effectively because of the dataset's binary size.

Previous work inform that gender ratio of ASD is around 4:1 M:F [32], [33] The prevalent belief that there is a 4:1 male-to-female ratio in ASD is untrue; the true ratio is lower, that is, lower than 3.5:1. This is a contentious ratio regarding multiple factors[18]. In our work we are examining the disparities between genders in the prevalence of ASD, particularly as it relates to new-born jaundice and found the result closer to the previous standard outcome.

CHAPTER 3

Methodology

As part of the technique, this study thoroughly pre-processes the data to make sure it is ready for analysis. This includes encoding categorical features and addressing missing values. Then, it uses python statistical calculation and visualization techniques to see the outcome. To determine the result in a visual way this study use different charts like pie chart, bar chart. By highlighting the MFR of how neonatal jaundice could impact the development of ASD, it hopes to make a significant contribution to the field of ASD disease detection.

3.1 Dataset Details:

This study utilize the "Autistic Spectrum Disorder Screening Data for Toddlers" dataset which compiled by Dr.Fadi Thabtah from the Manukau Institute of Technology, New Zealand, released on July 22, 2018. With autism spectrum disorder (ASD), a neurodevelopmental disorder linked to high healthcare expenditures, the dataset addresses the critical need for efficient, quick, and affordable screening techniques. We collect this dataset which is publicly available datasets from the GitHub repository (Dataset: Link) compiled by Dr.Fadi Thabtah [34], [35] and It has binary, continuous, and category properties. The dataset included 18 properties (including a class variable) and 1054 instances at first, as shown in table 1. The Quantitative Checklist for Autism in Toddlers (Q-CHAT) screening tool developed by Baron-Cohen et al. is the basis for the dataset used here [36]. Table 2 shows the use of a condensed version called Q-CHAT-10, which consists of ten questions. Class type is transferred to binary values according to the responses to these questions. Responding to the Q-CHAT-10 questionnaire is how these values are determined during the data collection procedure. When the QCHAT-10 score is higher than 3, it indicates the possibility of ASD features and is classified as the class value "Yes." If not, class value "No," which denotes the absence of ASD symptoms, is assigned [37]. There are no names or sensitive information in this dataset, therefore participant identities are anonymous [35].

Table 3.1. Details about the ASD dataset

Details	**Information**
Dataset source	Public repository GitHub
Data type	ASD Screening Data for Toddlers
Number of data	1054
Total features	18

Table 3.2. Feature mapping utilizing the Q-CHAT-10 screening technique

Dataset variable	Description
A1	Youngster reacting when you speak their name
A2	Getting a child to look at you with ease
A3	Youngster indicating what they want
A4	Youngster pointing to highlight his or her areas of interest
A5	If the youngster acts phoney
A6	Child's ease of following your direction of vision
A7	If the youngster desires to console an unhappy person
A8	First words of a child
A9	If the youngster makes simple gestures
A10	Should the youngster daydream or gaze at nothing

3.2 Data Pre-processing:

Before training the models, the datasets undergo pre-processing steps. This includes handling missing values (To replace the null values, we used the column mean that had missing data), and addressing class imbalance if present. To learn more about the distribution of the data and the connections between its aspects, data exploration and visualization techniques are used. Because data science uses these methods to identify and depict the underlying relationships, patterns, and insights in a dataset, this study employed them in our data exploration and visualization projects. These methods are essential for expressing findings clearly and making data-driven decisions.

CHAPTER 4

Result and Discussion

4.1. Experimental Setup:

The model was implemented using the Python programming language. Python is used in predictive analytics, Statistical analysis and data science projects involving both qualitative and quantitative data. Because Python is an easy language to learn and use, and has numerous built-in functions, many researchers have used it in the past. In studies centered on ASD [30], [37] used python language for their analysis. In our study Python packages pandas, numpy, seaborn, matplotlib were used to visualize and analyze the data.

4.2. Result Analysis

This study comprises 1054 cases from 2018 toddler (12-36 months) data. The results of the experiments on the ASD Screening Dataset using various Statistical techniques (Descriptive statistics, aggregate statistics), Conditional Filtering are reported in the form of graphs and tables. These graphs visualize the relation to neonatal jaundice and ASD and shows the gender ratio. Table 3 shows the Trend of Jaundice and ASD Patients by Gender.

Table 4.1. Trend of Jaundice and ASD Patients by Gender.

Gender	Count	Percentage	Ratio
Male	167	77.674	**3.479**
Female	48	22.325	

In This study first of all we try to figure out is there any null values in our dataset or not. We discover that is zero null values in our dataset, so we expect that this study will get better result.

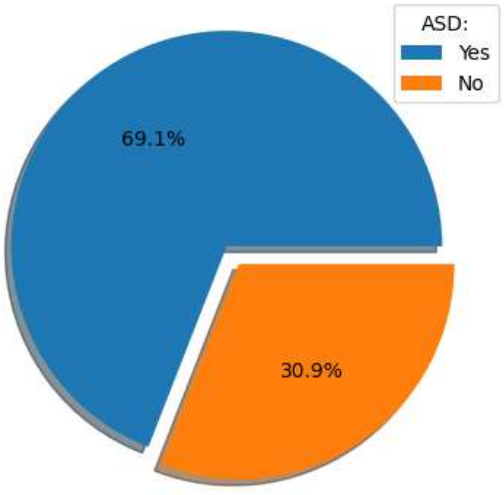

Fig 4.1: Presence of ASD disease

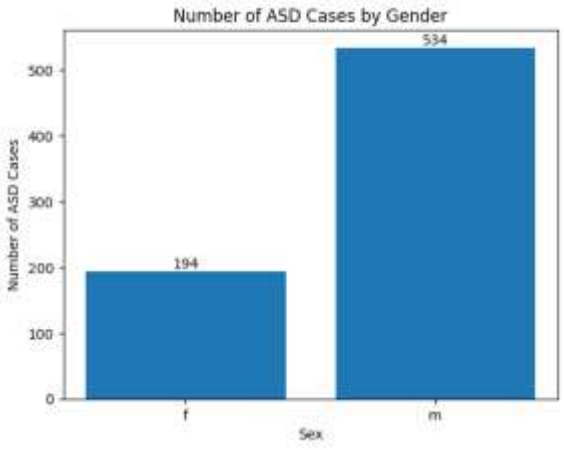

Fig 4.2: Number of ASD Cases by Gender

We try to figure out the presence of this disease, in figure 1 we saw that 69.1% are affected by ASD. From that 69.1%, 534 are male patients and 194 are female patients, which has been showed in figure 2. Then we try to figure out the ratio based on different criteria i.e, Age by Months, Ethnicity, Jaundice, Family member with ASD, who completed the test, Class/ASD Traits. In every criteria Male are most affected by this disease which is illustrated in figure 3. To make it more evident we test the ratio through questionnaire and it's Qchat score here also we found that man is most prone to ASD which has been shown below in figure 3. Now we can see from figure 4 that we have 288 jaundice cases where 215 are ASD positive with Jaundice and we found that the ASD rate is high when a toddler already has Jaundice (figure 5). From these 215 positive cases 77.7% are male and 22.3% are female (figure 6). So, the ratio is 1:3.479 which is moderate based on previous research [18].

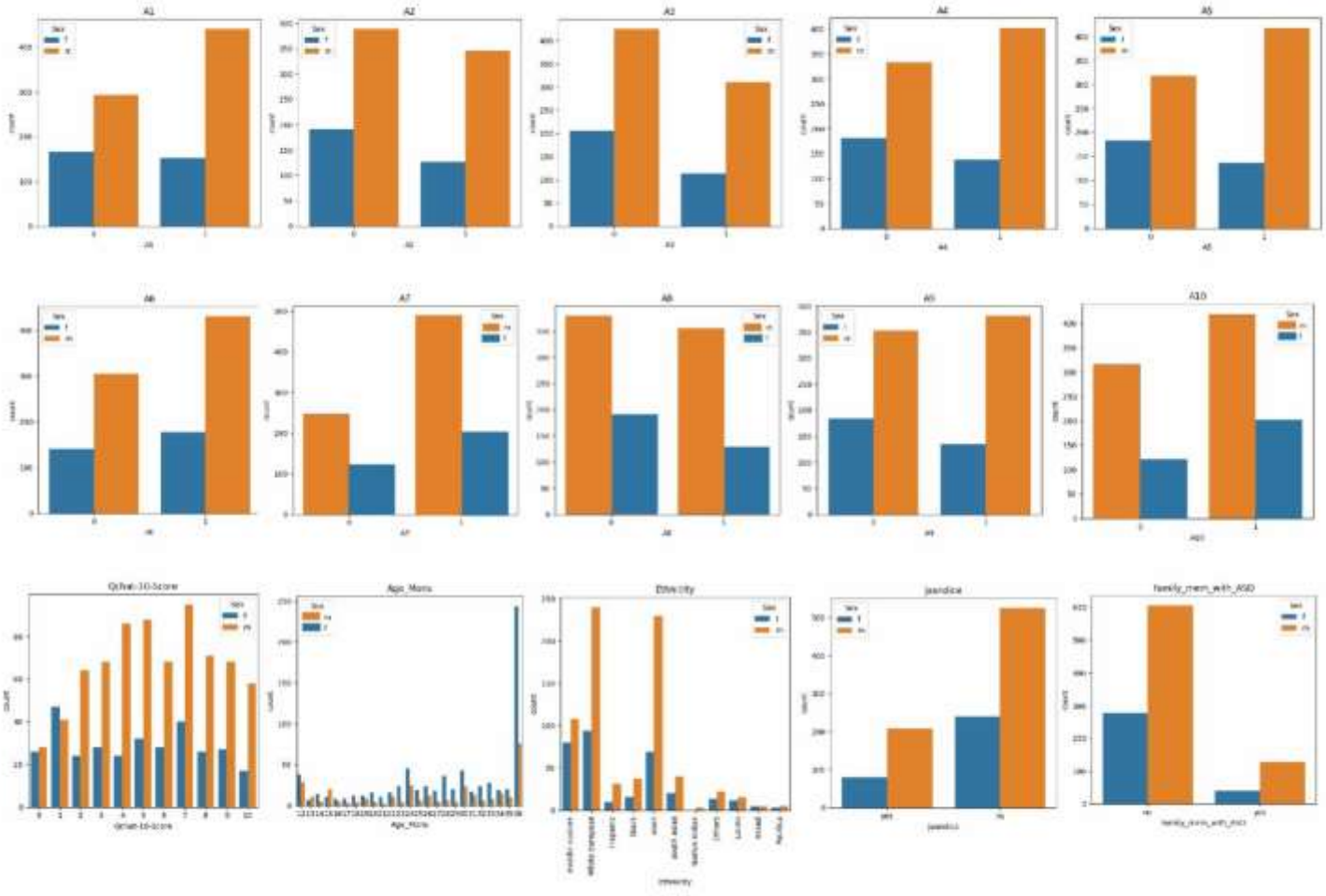

Fig 4.3: Male Female Ratio based on different criteria

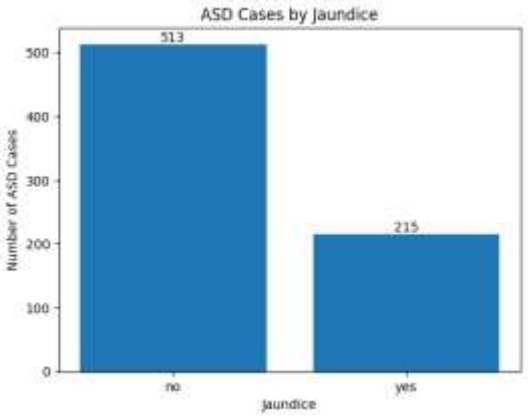

Fig 4.4: ASD positive case with Jaundice

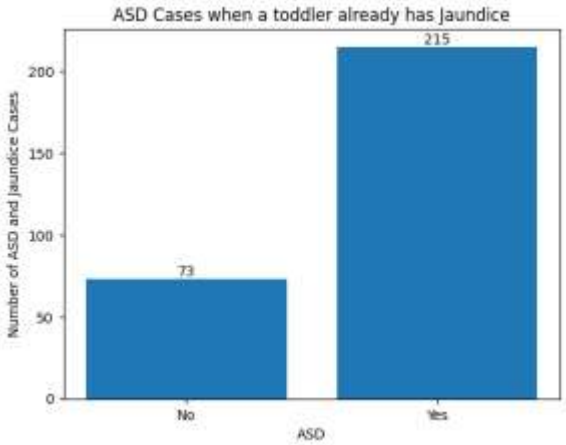

Fig 4.5: ASD Cases when a toddler already has Jaundice

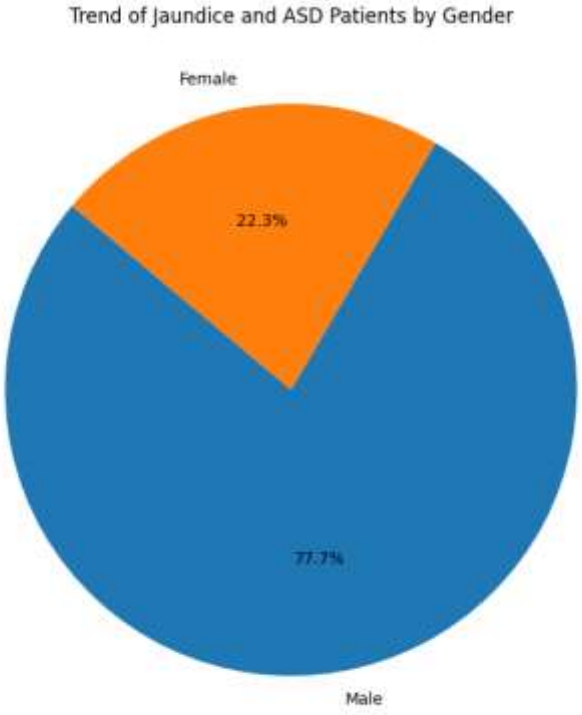

Fig 4.6: Male Female Ratio of ASD and Jaundice patient

Conclusion and Future Work

In this work, we looked at gender differences in the incidence of ASD in relation to new-born jaundice. The research yielded noteworthy findings, indicating a 3.479:1 male-to-female ratio in cases of ASD linked to new-born jaundice, with a much higher risk in boys. Moreover, a subgroup study encompassing various demographic and clinical characteristics, including age, ethnicity, and family history, validated the elevated risk observed in males. These findings highlight the vital requirement of early ASD screening in jaundiced new-borns, especially in boys, in order to enable prompt therapies. This study's dependence on secondary data has drawbacks, despite the insightful information it offers. In order to reduce biases related to retrospective data collection and to enable a broader generalization of the study's findings, larger prospective datasets are required for verification. Subsequent investigations ought to concentrate on pinpointing the fundamental processes via which infant jaundice could raise the likelihood of Autism Spectrum Disorder. This could entail investigating genetic predispositions that might combine with environmental triggers like jaundice, as well as thorough assessments of bilirubin levels and their direct impact on neurological development.

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02. Enrolment No .....

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05. Name of Department: SOFTWARE ENGINEERING

06. Admission Category i.e. Full Time/ Full Time (Sponsored)/ Part Time: Full TIME (SPONSORED) → ICCR

07. Applied as Regular/ Ex-student: REGULAR

08. Span Period Expired on .....

09. Extension of Span Period Granted or Not Granted (if applicable).....

10. Title of Thesis/Major Project: GENDER DIFFERENCES IN AUTISM SPECTRUM DISORDER: INVESTIGATING THE ROLE OF NEONATAL JAUNDICE

11. Name of Supervisor: DR. RUCHIKA MALHOTRA

12. Result Details (Enclose Copy of Mark sheets of all semesters) :

S. No.	Semester	Passing Year	Roll No.	Marks Obtained	Max. Marks	% of Marks	Details of Back Paper Cleared (if any)
01	1st	2022	2K22/DSC/19	6.94	10		
02	2nd	2023	2K22/DSC/19	7.41	10		
03	3rd	2023	2K22/DSC/19	8.42	10		
04	4th (P/T only)						
05	5th (P/T only)						

13. Fee Details (Enclose the Fee Receipt):

Amount Paid (in Rs.)	Receipt No.	Date
2,000	DUM6519835	20 / 05 / 2024

Signature of Student

It is certified that the name of Examiners for evaluation of the above thesis/ project have already been recommended by the BOS.

Signature of Supervisor

Signature of HOD with Seal

Professor & Head
Department of Software Engineering
Delhi Technological University
(Formerly Delhi College of Engineering)
Govt. of NCT of Delhi
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Category :	Miscellaneous Fees from students
Amount :	₹2000
University Roll No :	2K22/DSC/19
Name of the student :	Md Azizul Hakim
Academic Year :	2023-2024
Branch Course :	MTech DSC
Type/Name of fee :	Others if any
Remarks If any :	MAJOR PROJECT SUBMISSION FEE
Mobile No. of the student :	7428261289
Fee Amount :	2000
Transaction charge :	0.00
Total Amount (In Figures) :	2,000.00
Total Amount (In words) :	Rupees Two Thousand Only
Remarks :	MAJOR PROJECT SUBMISSION FEE
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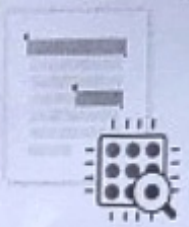

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DECLARATION

We/I hereby certify that the work which is presented in the Major Project-II/Research Work entitled Gender Differences in ASD: Investigating the role of neonatal Jaundice in fulfilment of the requirement for the award of the Degree of Bachelor/Master of Technology in M.Tech. Data Science and submitted to the Department of Software Engineering, Delhi Technological University, Delhi is an authentic record of my/our own, carried out during a period from 2022, under the supervision of Dr. Ruchika Malhotra.

The matter presented in this report/thesis has not been submitted by us/me for the award of any other degree of this or any other Institute/University. The work has been published/accepted/communicated in SCI/ SCI expanded/SSCI/Scopus indexed journal OR peer reviewed Scopus indexed conference with the following details:

Title of the Paper: Gender Differences in ASD: Investigating the role of neonatal Jaundice
Author names (in sequence as per research paper): Md. Azizul Hakim, Dr. Ruchika Malhotra
Name of Conference/Journal: 9th International conference on Research Developments in Applied Science Engineering & Management (AESM-2024)
Conference Dates with venue (if applicable): 15 May,
Have you registered for the conference (Yes/No)? Yes
Status of paper (Accepted/Published/Communicated): Published
Date of paper communication: March
Date of paper acceptance: April 28th
Date of paper publication: May 25th

Md. Azizul Hakim
2K22/DSC/13

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To the best of my knowledge, the above work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere. I, further certify that the publication and indexing information given by the students is correct.

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4. Degree for which the thesis is submitted: M.Tech, Data science
5. Faculty (of the University to which the thesis is submitted) Software Department

6. Thesis Preparation Guide was referred to for preparing the thesis.	YES ☑	NO ☐
7. Specifications regarding thesis format have been closely followed.	YES ☑	NO ☐
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Name(s): Dr. Ruchika Malhotra

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Name: Md. Azizul Hakim
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