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From the Desk of Editor-in-Chief

MESSAGE

I feel pride in publishing the sixth issue of 'Multidisciplinary International Research Journal of Gujarat Technological University'.

This issue concentrates on Engineering, Management and Pharmacy disciplines in which articles are written in different areas such as Farm on Wheels Technology, Big Data Analytics in Health Care, Work Engagement for Employees, Motorcycle Units for Motorcycle Dominated Traffic and Communication at Workplace.

I hope all these articles will be useful for their range of applications and will also open up new directions for further research.

I take this opportunity to thank the GTU editorial board members & international editorial board members for their efforts in upgrading the articles in this issue.

Dr. Pankajray Patel
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REPERCUSSIONS OF BIG DATA ANALYTICS IN HEALTH CARE – AN UPDATED REVIEW

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ABSTRACT

Health care is going to be complex due to the arrival of novel treatments, enhancing roles of providers, and changes in legislation, payment methods and healthcare information technology. The generation of big data due to fast adaptation of technology from a change of resources which are simple to complex in their content. The stakeholders of the healthcare system must recognize the need of big data and utilization of its elements for developing the models of pharmacy practice. To accurately analyze the enhancing volume of organized or unorganized biological and biomedical data from various sources such as laboratories, hospitals, pharmaceuticals companies, data mining and machine learning methods are frequently employed. The objective of this article is to offer a viewpoint regarding the application of big data towards healthcare systems. Big data can also increase the patient centered pharmaceutical service because information of health care is continuously expanding in terms of content and becoming more integrated. The current research including deriving application of a particular framework for healthcare proposes that data belonging to electronic health records to medical images can be handled by diversified data analytical techniques. The modern healthcare care companies can probably transform the personalized medicine and medical treatment with the help of robust amalgamation of healthcare and biomedical data.

Keywords: Big data, Predictive analytics, Internet on things, big data tools, Healthcare framework

1. INTRODUCTION:

There is a big challenge for data scientists for cautious assimilation and enactment of huge volumes of medical data gathered through diverse platforms. To encourage personalized and effectual treatment, it is imperative to assemble together analytics, health informatics and bioinformatics which will revolutionize the healthcare system (**Raghupathi & Raghupathi, 2014**). Moreover, to assess significant information from the structured, unstructured, semi structured and complex data innovative approaches and technologies should be cultivated (**Giudice, Musarella, Sofo, & Ursino, 2019**). The biggest advantage of big data is due to its immeasurable possibilities. The computational experts put more efforts to fabricate novel approaches to investigate and deduce the huge amount of medical data in a given time limit. There is a noteworthy impact of big data analytics on performance and decision making of the healthcare sector in a short span of time. The market of healthcare relied on big data is growing with an exponential rate anticipated by numerous healthcare consulting companies (**Dash, Shakyawar, Sharma, & Kaushik, 2019**). For building an improved predictive healthcare framework, medical data such as electronic health records (EHR), electronic medical records (EMR) is constantly assisting. A prospective solution for big data analysis is Quantum computing (**McGeoch, 2014**). Quantum annealing is used for optimization of beamlet intensity through intensity modulated radiotherapy (IMRT). To enhance the ability of signal separation, a recurrent quantum neural network (RQNN) is implemented. To attain diverse goals during various stages of the drug discovery and development process, data mining methods can be

employed. The algorithms based on medical data mining are used to narrow down the search area and offer suggestions to domain professionals for hypothesis formation, analysis and experiments. Predictive analytics can also be employed in recognizing patients who can get maximum advantage of pharmacist intervention and also in assessing medical outcomes. Pharmacists can have an enhanced understanding of the risks associated with medication problems of patients by predictive analytics. The role of predictive analysis will be better, as additional patient data will become available. Healthcare analytics are classified into four types, descriptive analytics deals with the data gathered from past offers understandings about trends and benchmarks **(Raghupathi & Raghupathi, 2013)**. The predictive analytics employs forecasting and modeling to decide what is going to happen in future. The prescriptive analytics use machine learning to recommend a strategy by considering several inputs. In discovery analytics, machine learning used to investigate the raw data to establish connections, patterns and outliers **(Muneeswaran et al., 2021).**

2. **CONCEPTS OF BIG DATA:**

It is defined as an enormously huge and complex database that accumulates dissimilar types and scale of information, collected from multiple sources. Big data related to healthcare include clinical trial data, electronic health report, administrative claims etc. Big data processing includes data feeding to the system, data preserving in storage, data computing and analyzing, outcome visualization **(Senthilkumar, Rai, Meshram, Gunasekaran, & Chandrakumarmangalam, 2018).** The clustering software of big data cartel the smaller machines resources, offering numerous advantages such as pooling of resources, High availability, and easy scalability. Due to the healthcare information digitalization, there is a surge of healthcare big data & value based care, stimulating the healthcare industry to employ data analytics to make professional decisions strategically **(Pramanik, Lau, Demirkan, & Azad, 2017)**. Healthcare industry is dealing with numerous challenges regarding the volume, variety, velocity & veracity of healthcare data. Big data plays a vital role in stimulating health care innovation which is affected by numerous financial models such as the need of patient, motivation of provider & technology advancement **(Kumari, Tanwar, Tyagi, & Kumar, 2018)**. Big data is efficiently providing the best treatment option to patients and providers which are based on population statistics.
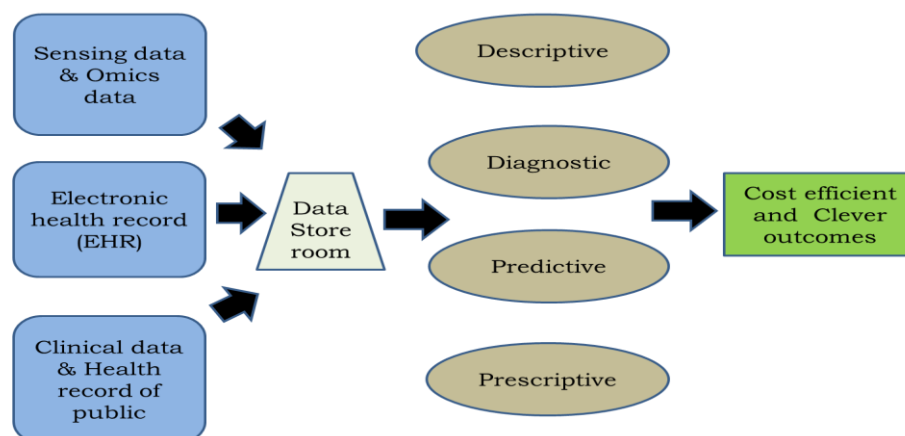
Figure 1: The working concept of big data analytics

2.1 Types of big data:

It is found in three forms:

- Structured data: The data which is accessed, stored & processed in fixed form format called as 'structured data'.

- Semi-structured data: This types of data consists both the forms such as fixed and unknown format.
- Unstructured data: The data which is available in unknown format or scattered structure known as 'unstructured data' **(Kitchin & McArdle, 2016**).

2.2 Tools of big data for healthcare system:

2.2.1 Data integration:
It provides elite prescriptive analytics for huge amounts of data, facilitating organizations for choosing cleverer decisions. Data lakes and cloud provide a platform for data integration which performs automated pipelines of data at a quicker rate (Palanisamy & Thirunavukarasu, 2019). It offers facilitation of data integration by employing on premise applications and saas based cloud services in a smart manner **(Dong & Srivastava, 2013).**

2.2.2 Visual data analytics:
It offers interactive analytics which are visual in nature at large scale with the help of information extraction by one or more sources. It gives quicker, superior interactive dashboards for the projection of extracted patterns. It provides operational and clinical data with the help of visual analytics for insights discovery **(Keim, Mansmann, Schneidewind, Thomas, & Ziegler, 2008**).

2.2.3 Stream data processing:
There is a tool available for in memory computing of data regarding real time analytics. (SAP Hana 2017). It offers a tool which can process the unbounded stream data in scalable, dispersed and fault lenient manner. (Neumeyer et al 2010). There is a tool which gives help for the generation of distributed streaming applications that supply real time data integration, ingestion and analytics **(Cortés, Bonnaire, Marin, & Sens, 2015)**

2.2.4 Machine learning:
To process scalable mining algorithms, it provides a distributed machine learning library. There is a tool which performs advanced analytics and performs machine learning of gigantic data at extraordinary speed **(Char, Abràmoff, & Feudtner, 2020)**. It is offering solutions by using predictive analytics for big data cases. There are various machine learning techniques for big data of healthcare such as Supervised learning, Unsupervised learning, Reinforcement learning, Semi supervised learning, Self-supervised learning, Multi instance learning, Inductive learning, Transductive learning, Online learning, Transfer learning, Ensemble learning and Deep learning. Amongst these all learning, Deep learning is widely used for drug discovery and development, medical insurance fraud investigation, analyzing disease with the help of MRI, ECG and CT Scan, Genome understanding and early detection of Alzheimer's disease. Along with that there is some other learning techniques include kernel based learning, transfer learning; active learning, representation learning distributed and parallel learning are also play vital role in big data analysis **(Dhillon & Singh, 2019**).

2.2.5 Searching and processing:
It offers worthy programming constructs along with a superior performance distributed execution engine. It provides complements which are based on map computations backed by Hadoop for nested data processing with extraordinary scalability. There is a search engine available for accomplishing full text search on various platforms having superior performance **(Höög, Lysholm, Garvare, Weinehall, & Nyström, 2016**).
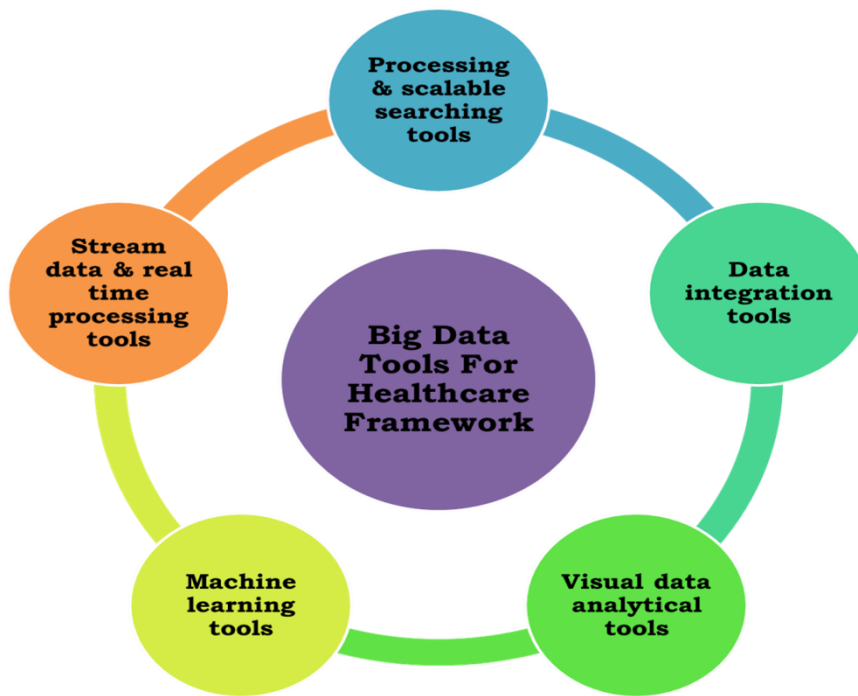
Figure 2: Different tools of big data used for development of healthcare system

3. **Electronic health records (EHRs):**

The national institute of health is collecting more than one million electronic health records of patients which include environmental data, medical imaging data and socio behavioural data. EHRs are offering numerous benefits in the management of data related to the recent healthcare system **(Yadav, Steinbach, Kumar, & Simon, 2018**). The medical practitioner has an enhanced access regarding the patient's medical history including prescriptions, medical diagnosis, allergies data, demographics, clinical descriptions and data gathered from numerous laboratory tests. Due to decline in such errors, there is diminishing in the cases of allergies by dropping errors in dose and frequency of medication. EHRs can diminish or abolish the confusion in the management of billing and claims. EHRs also give significant data of health insurance programs for quality care of the patients and also provide assistance to minimize the cost of health insurance. This electronic platform facilitates medical practitioners to develop their consultation by employing automatic reminders, vaccinations, abnormal laboratory outcomes, screening of cancer. These periodic involvements in between patients and providers of healthcare will enhance the superior care of patients **(Haas, Wohlgemuth, Echizen, Sonehara, & Müller, 2011**).

4. **Healthcare and Internet on things (IoT):**

IoT is an emerging player of the healthcare industry and has become an integral part of industry **(Yeole & Kalbande, 2016)**. The information & communication system such as near field communication (NFC) and radio frequency identification tags (RFID) are widely employed in the healthcare industry **(Khosravi, Karbasi, Shah, Brohi, & Ali, 2016)**. One can get critical information after analyzing the data from these devices which can be beneficial in the field of healthcare. IoT devices are chief contributors of big data in terms of observing the people's health. The data obtained from these reliable sources can be utilized to offer trustworthy and effectual treatment to patients with a chronic illness. There is a noteworthy decline in healthcare costs by intervention of IoT. Various IoT devices such as health tracking devices, biosensors, clinical services for evaluating vital statistics are used frequently by healthcare professionals. We can assimilate this data with already existing data such as electronic medical records (EMRs), resulting in the better forecasting of health status of patients **(Yuehong, Zeng, Chen, & Fan, 2016).**

Big data also helps in finding ways for specific outbreak of disease. An advanced hardware and updated software needed for the analysis of data through IoT. The stakeholders related to the healthcare system are trying to reduce the cost and enhance the quality of care by using big data analytics. Various organizations are using artificial intelligence to analyze the published reports to make big data analytics easier. Watson health of IBM is serving a platform for data sharing and analyzing to hospitals and researchers. In case of cancer research, Flatiron health is offering diverse technology related services towards healthcare big data analytics.

Table 1: Various software available for healthcare analytics (Xu et al., 2018)

Name of company	Solution provided	Url
Enlitic	Offer deep learning healthcare diagnosis by employing huge scale data sets from clinical tests	www.enlitic.com
Linguamatics	Offer platform for useful information through unorganised healthcare data by mining of text	www.linguamatics.com
Roam analytics	Gives infrastructure for natural language processing for contemporary medical systems	www.roamanalytics.com
Ayasdi	Offer analytics platform based on artificial intelligence (AI) for risk management, clinical changes	www.ayasdi.com
Lumiata	It drives data transformation so one can better predict costs and manage risks.	www.lumiata.com
Optum Health	It is committed to provide best health services, leading way to better experience at lower cost for you.	www.optum.com
Apixio	Our AI solutions for risk, quality, and clinical insights unlock actionable information from administrative data and unstructured clinical information.	www.apixio.com

5. **Analysing healthcare big data by various approaches of data mining:**
   In health care and pharmaceuticals, a massive amount of data is generated every day. As the enhancing awareness regarding the data as an imperative asset, novel data mining approaches are coming to market to get the benefit of large volumes of data. There are some approaches which are utilizing data analysis such as classification, clustering, regression analysis and rules of data association (**Mdaghri, El Yadari, Benyoussef, & El Kenz, 2016**).

5.1 Classification of data:
It is the most efficient and effective process for data organization. It is the most widely used method for data mining in the healthcare sector. Classification consists of two steps, training and testing. In 2015 Macrae *et al* employed a pattern recognition method to identify respiratory conditions of infants by forming an algorithm for unstructured data classification written by medical practitioners at primary care consultations (**MacRae et al., 2015**). In 2015 Azar *et al* provided a new neuro fuzzy classifier having particular features for selection, reduction in dimensionality and classification (**Azar & Hassanien, 2015**). In 2012 Estella *et al* fabricated an innovative system for classification of medical resonance imaging (MRI) images of patients suffering from neurodegenerative disease. The chief reason is to fabricate this system to get assistance in decision making for classification tasks.

5.2 Clustering of data:
It is a different method from classification. There is no predefined classification in this type of data mining. Clusters are, when a huge database is distributed into small no of groups. The data

is divided on the basis of similarities. The algorithms of clusters that have the same cluster consist of data, are more similar in nature to each other in comparison to other groups (**Kerr, Ruskin, Crane, & Doolan, 2008**). In 2014 Jaskoviak *et al* investigated the clustering methods employing gene annotation to evaluate the quality of gene expression (**Jaskowiak, Campello, & Costa, 2014**). In 2015 Kar *et al* also studied the data of gene expression by employing categorized clustering methods by employing genetic algorithms (**Kar, Sharma, & Maitra, 2015**). In 2016, Liao *et al* applied various clustering approaches to ascertain the expenditure patterns of patients, started hemodialysis for end stage renal disease (ESRD) (**Liao, Li, Kianifard, Obi, & Arcona, 2016**).

5.3 Data association:

It plays a vital role to find out the relationship between disease, human health condition and disease symptoms in the healthcare industry. The competences of data mining techniques are enriched by employing assimilated approach of classification and association techniques. Rashid *et al* (2014), have employed association rules of data mining to find out the disease pattern carried by a patient. They have fabricated a prototype system for clinical state correlation prediction (CSCP), which mines the data from healthcare database of patients, then converts the online transactional processing (OLTP) data into data warehouse by creating rules of association (**Rashid, Hoque, & Sattar, 2014**).

Lakshi *el al* (2017) employed multiple-criteria decision analysis to choose the precise rule of association mining algorithm for association rules extraction from medical records (**Lakshmi & Vadivu, 2017**).

This unified methodology is employed to determine the database rules and an efficient classifier is developed on the basis of these rules.

5.4 Regression analysis:

It is commonly employed method in investigating big data of healthcare for assessing the relationship between properties or variables. It consist various researches concern such as data sequence forecasting, associations among data and data sequence trend features.

In 2017, Wan *et al* mentioned factors contributing to patient satisfaction and also offer an algorithmic method to evaluate it from analysis of healthcare big data (**Wan & Alagar, 2017**).
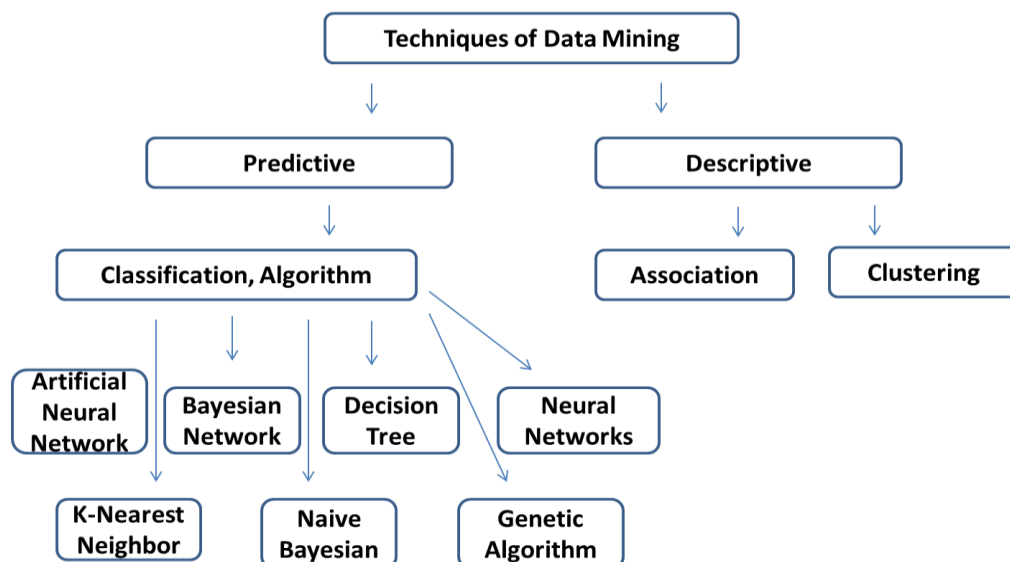
Figure 3: Classification of data mining approaches

6. Big data and patient care optimization:

The role of big data analytics is vital for implementation of EBM in true manner. For proper implementation of EBM, diverse data analytical methods such as Spark, Hadoop, Mapreduce, Mahout is used **(Roy, Rautaray, & Pandey, 2018)**. Amongst all Hadoop is widely employed open source distributed platform of data analytics for data distribution. There are two types of data sources internal and external. Usually clinics provide the data known as internal data sources. These data proofs are extracted from clinical trials and decision support system. The government sources, insurance company, laboratories are chief source of external data source. These data derived in different formats such as .csv, flat files, relational tables and ASCII/text. The big data is also play crucial role for pharmacovigilance involving new electronic approaches that are employed to investigate big and surging volume of information regarding adverse drug reaction IN database of spontaneous reporting system (SRS). Data mining is widely employed to identify the fresh drug-adverse drug reaction relations regarding drug safety investigation process **(Ventola, 2018)**.
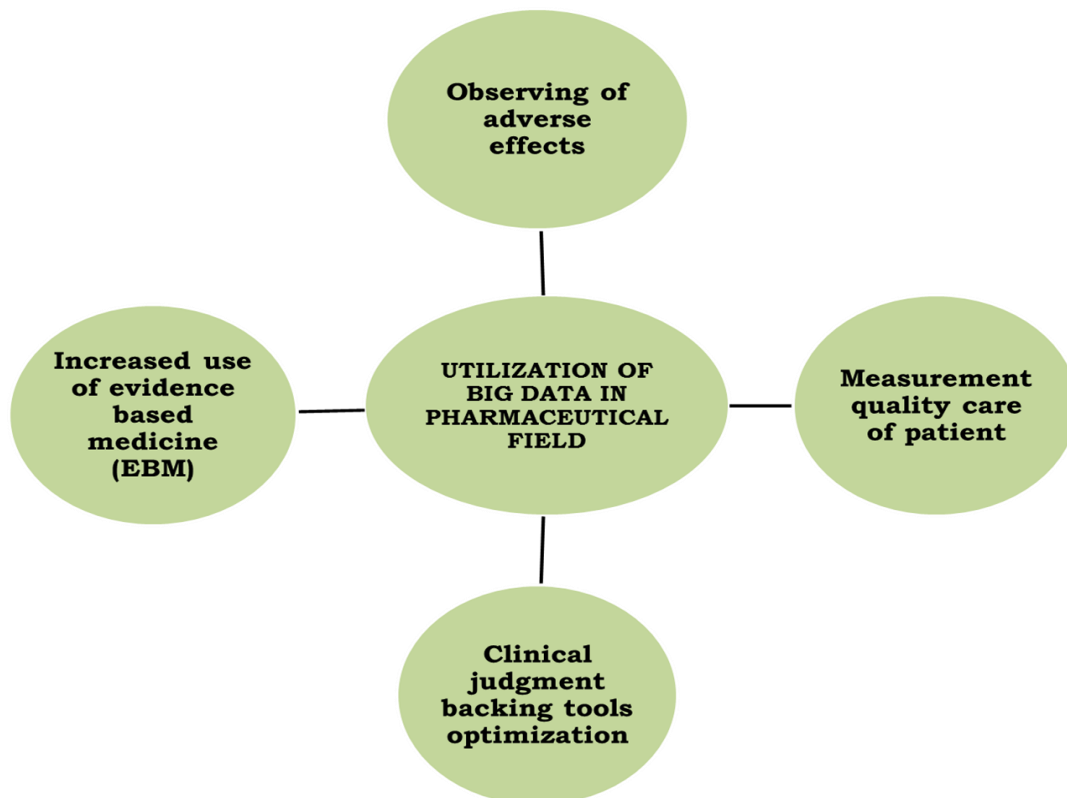
Figure 3: Management and operations of pharmaceutical system using big data

7. **Challenges associated with big data analytics:**
There is a big challenge related to collection, protection and sharing of healthcare data. There is the possibility of data transformation by using sophisticated technologies of big data analytics. There are some concerns related to privacy, security, governance and standards should be addressed properly, to mitigate the wrong use of this data **(Acharjya & Ahmed, 2016).**

7.1 Data analyst/Data scientist:
It is still a strenuous task to find people having expertise in computer science or information technology along with statistics. Additionally encouraging the growth of healthcare big data

analytics requires analysts having sound knowledge of clinical and analytics. We need personnel who are masters in data processing technology and medical data management. They can apply the specific management model to build the infrastructure of data, an unremitting platform of application & research, confirm steadiness and attain cross cutting cooperation **(Asamoah, Sharda, Hassan Zadeh, & Kalgotra, 2017)**.

7.2 *Retention and management of big data*:
The data related to healthcare should be available for at least 5 years. There is a need for long term data tracking accessed for which purpose and by whom it is accessed. The collected healthcare data require proper formatting, checking for accuracy and made available for diverse purposes such as billing, clinical & administrative. The management of huge volume and velocity of this data is very challenging **(Ahmed et al., 2017)**.

7.3 *Challenge related to privacy & security of big data:*
The data issues related to privacy & security are very imperative for healthcare business. Successful theft of healthcare data is very beneficial for criminals, at the same time tremendously detrimental for healthcare institutions. The health records consist of personal data ranging from lab tests, diagnosis and details of credit card too. So data breaching will be highly damaging to the individual. There are some other challenges such as data encryption, masking of data and data protection stringent methods are facing by healthcare providers **(Peek, Holmes, & Sun, 2014)**.

7.4 *Mismanagement between clinical and administrative systems:*
The medical records and billing details retained by healthcare personnel of hospitals should be accurate when dealing with insurance claims. But it is quite often that there is a gap found in treatment codes of patients between clinical and administrative systems regarding management of such data **(Lee & Yoon, 2017)**.

7.5 *Patient data sharing to other stakeholders:*
For easy and rapid access, maximum records of patients are kept in a centralized database. The actual challenge encountered when this data is to be shared to other stakeholders other than medical practitioners. It is a cumbersome task for pharmacies & external healthcare providers to get such kind of data **(Mittelstadt & Floridi, 2016)**.

7.6 *Data simulation and modelling:*
Big data is ideal for modeling and data simulation, but the prerequisite is to recognize, arrange and pool the appropriate data so it can be employed to diverse models. It is very challenging to envisage and investigate the results and precise data extraction without proper data structuring **(Giabbanelli, 2019)**.

8. Applications to analyze healthcare big data
Big data offer extensive sustenance to analyze the healthcare data. It has done the progress towards diverse areas such as public health, analysis of disease pattern, personalized medicine and medical information services. There are some applications which provide excellent results in clinical decision support system **(Kumar & Singh, 2018)**.

8.1 *The Help system:*
It is the first ever clinical decision making system which offers the health characterization by employing logical processing system. This system takes decisions by utilizing clinical data of diverse sources which is stored in its clinical database. This system consist accounting system, a knowledge base, processor for decision making, time and data driver, repository of patient data and alerts of data reviews. This system is also capable in making decisions which are time driven.

8.2 The MYCIN system:

This system offers exceptional results for the diagnosis and treatment of infection related to central nervous system. There are three subsystems exists in this namely consultation, interpretation and rules. It make clinical recommendation and assisting physicians to determine the species of bacteria by imitating knowledgeable reasoning process which is based on clinical indication and laboratory outcome of patients.

8.3 The QMR system:

This system is one kind of clinical decision support system (CDSS) which provides help to medical practitioners by employing Internist-1 or Caduces knowledge base. This knowledge base is quite similar like a medical book which contains 6000 clinical symptoms, 40,000 disease relationships and 1000 disease. It is one of the earliest clinical support system employ probability raking system and artificial intelligence. One limitation of this system is that the knowledge base of QMR has to be updated regularly.

8.4 The ILIAD system:

This system is developed by School of medicine, University of Utah known as medical expert consultation system. This system comprises 4 main components such as the data driver, the information algorithm, user interface and engine of inference. It is widely employed consulting tool for teaching and simulation training of CDSS. The Bayestan and Boolean frames is utilized to represent the knowledge of this system. The mentioned frames allow the usage of specificities and sensitivities to explain the disease relationship to its signs which deliver a rational to explain its outcomes. The consultant working with Iliad uses various inferencing mechanisms to match the medical practitioner strategy on his patient.

9. Conclusion:

There is superb potential in big data which can alter the healthcare scenario related to patient safety management, drug discovery, perfection in clinical evaluation, effectiveness in treatment, personalization care of patients. As there are huge data records in the medical industry so it is necessary to employ data mining techniques to get support in decision making and prediction to recognize the type of disease. One can get the specific information from these mining techniques which will be beneficial for diagnosis of disease.

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A STUDY ON WORK ENGAGEMENT FOR EMPLOYEES OF FINANCIAL INSTITUTIONS

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Abstract

Researchers have done survey on work engagement for employees of financial institutions using Utrecht Work Engagement Scale (2003) which is much more important in business performances and successes. It is assumed to have varied employee behaviour in service sectors and hence financial institutions were considered for this research. Responses were received from 200 sample units working as employees in various financial institutions across the Gujarat. Data analysis was carried out using ANOVA, reliability analysis and exploratory factor analysis. The study concludes identification of two important variables namely Work Satisfaction and Job involvement. So, financial institutions need to focus on these two variables for increasing the level of work engagement.
Keywords: Work Engagement, Financial institutions, Work Satisfaction, Job Involvement

Introduction

Work engagement has developed as a common organizational concept in recent years. Work engagement is based on vigour, dedication, absorption, faith, honesty, promise from both sides- employee & employer and communication between the firm and its employees. Successful work engagement paves way for the business prosperity, increase in the efforts of the employee, overall productivity and well-being of the organisation. Work engagement can be the employee's quantum of commitment and his/ her involvement towards the organisation and the values practised in that organisation. So the employee displaying work engagement is always knowing the present condition of the business operations of the organisation and he cooperates as a team member to increase the level of business operations which ultimately guides the organisation towards success.

This means that work engagement is a phenomena that is complex in nature and important for the business unit and so one needs to comprehend it and elaborate on the various approaches for identifying its nature. Initially Kahn (1990) coined engagement at work as the harnessing of employees of organization to their work roles. Employees show their engagement towards their work in an organisation physically, cognitively, and emotionally when they are performing their role in the organisation. So Work engagement can be conceptualised as the employee's level of commitment and involvement for his/ her organization and its values. For the enrichment of the organisation an engaged employee knows the context of business of the organisation, and he/ she teams up with fellow employees for a superior output within the job role defined for him/ her in the interest of the organization. So it is always good for an organization to put in efforts that initiate, nurture and engagement in a symbiotic relationship with the employees. Thus Work engagement is a result oriented tool use to identify the employee's relationship with the organization. Engagement is almost associated with the theory of job involvement. Job involvement is defined as 'the degree to which the job situation is very much important to the person and his or her image. ' (Lawler & Hall, 1970). Kanungo (1982) says that job involvement is a 'Rational or belief state of mental identification.' Job involvement is perceived to rely on both need saliency and the possibility for a job to satisfy these needs. Thus job involvement results form a mental cognitive assessment about the needs satisfying abilities of the job.

Literature Review

As cited by Kahn (1990:694) earlier, work engagement is reflected in the performance of the employee through their job role in a cognitive, emotional and / or physical way during role performances. Cognitively, work engagement relates to the beliefs about the organization, its leaders and working conditions that an employee has. The emotional aspect relates to the emotions an employee has about each of those three factors and also if he/ she possess a favourable or unfavourable attitudes toward the organization and its leaders. The physical aspect relates to the physical labour and time put in by the employee to fulfil his/ her job role. Thus as per Kahn (1990) Work engagement is a multifaceted construct comprising of cognitive, emotional and physical domains.

Other authors have also defined work engagement as emotional and intellectual commitment to the organization (**Baumruk 2004**). **Frank et al (2004)** conceptualised work engagement as the level of efforts which can be characterised as discretionary, put in by employees in their job. **Truss et al (2006)** opposes Kahn (1990) and instead defines work engagement as uni-dimension construct and naming it as 'strong desire for working towards the job role defined', a mental state which includes the three domains of work engagement namely, cognitive, emotional and physical domains and also capturing the common idea running through all these definitions.

So because of the multiple definitions of work engagement present in the literature it becomes a complex construct and so poses difficulty in determining its true nature as each study examines work engagement under a different conditions prevalent in the organisation. So in the nonexistence of a universally defined construct, the measurement of work engagement, its management becomes difficult and so the efforts to improve it cannot be identified. (**Ferguson 2007**).

Engagement is more than simple job satisfaction and high retention rates. Fully engaged workers are those who are physically energized, emotionally connected, mentally focused, and feel aligned with the purpose of the agency (**Loehr & Schwartz, 2003**). Engaged employees have a bond with the organization. These individuals feel empowered and in control of their fate at work. They identify with the agency mission and are willing to commit the necessary emotional and personal energies necessary to excel in their work. But for this study because of the popularity of Kahn (1990), the researchers decide to utilise his scale for measuring work engagement in financial institutions in Gujarat.

Research Methodology
Objectives
- To study overall work engagement for employees of financial institutions
- To identify the factors structure of work engagement
- To study the impact of demographic variables on work engagement

Hypothesis
H_0: There is no significance variance across different levels of management, years of experiences and education level for work engagement
H_0: There is no relation between factors of work engagement

Research Design

As the research is based on the concerned conditions, relationships that exist, opinion that would be held, processes that are going on, effects that are evident and trends that are developing, so the research design was descriptive research design.

Data Collection

Survey method used for collecting the data for the study. Survey method covers overall assessment of a respondent about any object and his or her favourable or unfavourable opinion about it. For collecting information, the structured questionnaire has been filled by employees of various financial institutions.

Sampling

The convenience sampling method has been used to select the sampling units

Research Instrument

Structured questionnaire of Utrecht Work Engagement Scale (UWES) comprising of 17 items was used for this research.

Reliability Analysis

Reliability Statistics (Table 1)		
Scaled factor	Cronbach's Alpha	N of Items
Vigor	0.94	06
Dedication	0.943	06
Absorption	0.938	05

As Cronbach alpha of inter-items is more than 0.6 for all the three factors, the UWES scale used in this research is reliable.

Data Analysis & Interpretations

A)   Measurement of overall work engagement

Descriptive Statistics		
	N	Mean
1 At my work, I feel bursting with energy	200	3.94
2 I find the work that I do full of meaning and purpose	200	4.08
3 Time flies when I'm working	200	3.72
4 At my job, I feel strong and vigorous	200	3.69
5 I am enthusiastic about my job	200	3.77
6 When I am working, I forget everything else around me	200	3.42
7 My job inspires me	200	3.67
8 When I get up in the morning, I feel like going to work	200	3.65
9 I feel happy when I am working intensely	200	3.76
10 I am proud on the work that I do	200	3.72
11 I am immersed in my work	200	3.51
13 I can continue working for very long periods at a time	200	3.50
14 To me, my job is challenging	200	3.34
15 I get carried away when I'm working	200	3.16
16 At my job, I am very resilient, mentally	200	3.39
17 It is difficult to detach myself from my job	200	3.35
18 At my work I always persevere, even when things do not go well	200	3.35
Grand Mean Score		3.6

Interpretations:

Overall work engagement grand mean score is 3.6 on a scale of 1 to 5 where 1 represents strongly disagree and 5 represents strongly agree, so the grand mean score indicates positive level of agreement towards work engagement of these employees in their respective financial institutions

(Table 4) Rotated Component Matrix[a]			
	Component		
	1	2	3
1 At my work, I feel bursting with energy			.751
2 I find the work that I do full of meaning and purpose			.761
3 Time flies when I'm working	.678		
4 At my job, I feel strong and vigorous	.774		
5 I am enthusiastic about my job	.787		
6 When I am working, I forget everything else around me		.760	
7 My job inspires me	.773		
8 When I get up in the morning, I feel like going to work	.804		
9 I feel happy when I am working intensely	.796		
10 I am proud on the work that I do	.815		
11 I am immersed in my work	.559	.655	
13 I can continue working for very long periods at a time	.682	.507	
14 To me, my job is challenging		.704	
15 I get carried away when I'm working		.879	
16 At my job, I am very resilient, mentally		.592	
17 It is difficult to detach myself from my job		.702	
18 At my work I always persevere, even when things do not go well		.621	
Extraction Method: Principal Component Analysis.			
Rotation Method: Varimax with Kaiser Normalization.			
a. Rotation converged in 6 iterations.			

B)   **Exploratory Factor Analysis for Work Engagement Scale**

KMO and Bartlett's Test (Table 2)		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.961
Bartlett's Test of Sphericity	Approx. Chi-Square	4.560E3
	df	136
	Sig	0.000

Total Variance Explained (Table 3)									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	12.820	75.412	75.412	12.820	75.412	75.412	6.417	37.745	37.745
2	0.974	5.732	81.144	0.974	5.732	81.144	5.032	29.598	67.343
3	0.505	2.972	84.116	0.505	2.972	84.116	2.851	16.773	84.116
4	0.417	2.455	86.571						
5	0.377	2.217	88.788						
6	0.320	1.882	90.669						
7	0.260	1.529	92.198						
8	0.233	1.368	93.566						
9	0.215	1.263	94.829						
10	0.185	1.085	95.915						
11	0.146	0.860	96.775						
12	0.130	0.765	97.540						
13	0.107	0.629	98.169						
14	0.095	0.560	98.729						
15	0.086	0.507	99.237						
16	.077	.454	99.691						
17	.053	.309	100.000						
Extraction Method: Principal Component Analysis.									

Interpretations:

As per table 2, KMO and Bartlett's Test was significant so EFA is possible. Table 3 shows that the total variances across three factors identified are 84.116 which imply that the scale measures almost 84% of work engagement in the financial institutions. Also, the first two factors contribute 37.745 and 29.598 % of total variances respectively.

As per table 4, first factor comprises of 7 items and second factors comprises of 6 items. As the third factor comprises of only 2 items, it is not being considered.

Based on the items that contributes to the first factor, it is named as Work Satisfaction and second factor, is named as Job involvement. This research concludes that the work engagement scale comprises of only important factors namely; Work Satisfaction and Job involvement for the financial institutions in Gujarat.

C) ANOVA

H_0: There is no significance variance across different levels of management, years of experiences and education level for work engagement

ANOVA (Year of Experience vs Work Engagement) Table 5		Sum of Squares	Sig.	Decision for H0
Work Satisfaction	Between Groups	6.165	0.412	Not accepted
	Within Groups	418.724		
	Total	424.889		
Job Involvement	Between Groups	7.197	0.236	Not accepted
	Within Groups	329.217		
	Total	336.413		
ANOVA (Level of Management vs Work Engagement)				
Work Satisfaction	Between Groups	2.749	0.528	Not accepted
	Within Groups	422.140		
	Total	424.889		
Job Involvement	Between Groups	3.240	0.386	Not accepted
	Within Groups	333.174		
	Total	336.413		
ANOVA (Education vs Work Engagement)				
Work Satisfaction	Between Groups	6.165	0.412	Not accepted
	Within Groups	418.724		
	Total	424.889		
Job Involvement	Between Groups	7.197	0.236	Not accepted
	Within Groups	329.217		
	Total	336.413		

Interpretations: As per ANOVA table, it is concluded that defined null hypothesis is not accepted. Hence, the demographic variables of levels of management, years of experiences and education level affects work engagement.

D) Correlation

H0: There is no relation between factors of work engagement

Correlations Table 6				
		Average of 7 items	Average of 6 items	Decision for H0
Work Satisfaction	Pearson Correlation	1	0.849**	Accepted
	Sig. (2-tailed)		.000	
	N	200	200	
Job Involvement	Pearson Correlation	0.849**	1	
	Sig. (2-tailed)	.000		
	N	200	200	
**. Correlation is significant at the 0.01 level (2-tailed).				

Interpretations: There is no Correlation between identified factors, work satisfaction and job involvement. But both contribute to the measurement of overall work engagement for employees of financial institutions.

Conclusion

This research concludes that overall work engagement for employees of financial institutions is positive level of agreement. From the structured UWES-17 items scale, two important factors, namely work satisfaction and job involvement were identified for measuring overall work engagement. Though, these factors are not inter-related with each other but they combined contribute for work engagement for employees of financial institutions. Research study shows that the demographic variables have effect on work engagement. Further studies can be done in different industries in different geographical areas to validate the work engagement.

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HOW MEN AND WOMEN DIFFER IN COMMUNICATION AT WORKPLACE: A STUDY PERTAINING TO IT CONSULTING AND APPLICATION SOFTWARE COMPANIES

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ABSTRACT

The topic of Gender Differences in Communication Styles has been of substantial interest to researchers within the field of psychology, management, and sociology, especially in recent years when women started taking leadership areas at supreme organizations. The correlation between gender and communication styles has been studied with main focus on differences between the communication styles of men and women from different perspective and different methodologies. The aim of this research is to investigate numerous approaches followed by men and women employees to communicate at the workplace. For doing this, it is inevitable to specialize in communication patterns of different genders. Quality research was conducted using a systematic questionnaire, which included 70 IT professionals including 35 men and 35 women aged 20 to 55 years. This project will be a testament to the many articles, journals and books published in the study to show how data flows to differentiate between men and women's communication channels.

Keywords: Gender Differences, Communication Patterns, Correspondence Styles, IT Professionals

INTRODUCTION

Communication assumes an extremely critical and urgent part in our day by day lives as it assists us with communicating our thoughts or perspectives before others subsequently building up our way of life as people. It is consistently significant at home and expertly its importance increments when we collaborate with our leaders, subordinates or partners at work place. The assumed natural and mental contrasts among people have for some time been liable to research and examination. The opportunity has arrived to understand the significance of men and women communication as seeing how the contrary gender orientation interfaces with one another can make the world a superior spot to live.

As an individual communication is quite possibly the main feature of public activity. Like never before in mankind's set of experiences individuals come into contact with individuals who are from different societies or of another gender orientation. Innovation makes it conceivable to travel quicker and further, the worldwide workforce is more versatile, and in numerous spots the labor force is getting more different as numerous individuals progressively end up working in global groups at home and abroad. Intercultural correspondence is in the core of hierarchical technique and is crucial to development and thriving.

Gender communication is the distinct part of communication domain which is focusing on how we as human beings having different gender communicate with one another. This research will be helpful in gaining understanding related to people of different gender and their insights in politics, media, sports or academia.

Men and women normally have various attributes. Information on these characteristics helps people, especially those of inverse gender, cooperate successfully in an association. It is expected of both men and women that the opposite ones behaves in the same order of ideas and behaviors. Measures that ensure equitable access to essential services and management are essential to achieving a responsive gender-responsive stability.

Gender sensitivity means the consideration of the individual for his or her gender. It includes more noteworthy attention to the necessities, goals, capacities, and expert worth of representatives as people, with no bias by their gender. The gender-sensitive work environment creates an ideal environment for the full utilization of staff in organizational planning. Therefore, it is important for people within the organization to know what a wide range of life options are for everyone.

LITERATURE REVIEW

Men and ladies contrasts psychologically within the manner they act, through the design in which they convey during the process of influencing others. Two elementary sides of research are there on differences in correspondence styles, scholastic investigation and popular writing of different gender. Conversation features and traits across gender has been brought about to make significant contrasts through academic research.

The main difference between the communication styles of men and women is that, as per them the purpose of communication is different. For women, communication is a tool to strengthen social connections and relationship and for men, it aids dominance manifest and to achieve concrete outcomes. Women are expressive, indefinite and humble and men are quite assertive and power-mad while communicating.

As per Maltz & Borker, 1982; Wood, 1996; Mason, 1994 research in the field of gender differences across styles of communication concludes that men are more of self-assertive. Alternatively women value cooperation. Women also are known to possess less clear specialize in ending of their boundaries and individual recognition. As per Gray, 1992 the major distinction in the style of correspondence of men are that they are career-focused, as for them to achieve results is the recognition of their own self. Contrarily if we see women, they are more of relationship-focused because as per them feelings and relationship are the results for self-recognition. The style of men to manage stress is by refraining themselves from the conversation itself. On the other hand women do this by talking about their matters of stress to friends, family or colleagues.

The focus of research regarding the way men and women interact with one another at workplace has governed on involvement and influence by the parties. As per research, men wish to keep the ground less frequently and for a shorter duration, use more interruptions, and make various kinds of endowment with the use of efficient language strategies required to maintain distinctions among status. Alternatively, women desire to keep the floor for a lesser duration and less frequently, they interrupt less, and employ language strategies which are of supportive nature and that lessen the distinctions of status.

Tannen 1994, in her analysis of men and women in the workplace, notes that women who have been seen

in management positions often give instructions to subordinates in ways that save their subordinates, and many men in similar positions often do not.

Eddleston, Veiga & Powell, 2003 proposed that the gender stereotypes of social nature are fitted from the very young age in our minds. Till reach four, children obtain understanding of relevant characteristics of the gender possess by them and they attempt to obey these roles. As per Welbourne 2005, stereotypes of this kind are revealed to an individual in the course of their childhood itself. Such gender roles having stereotypical nature function as regulation for conduct at workplace because they try to command subconsciously regarding in what way one should talk that supports the gender role. Such stereotypes could have exceptionally destructive results on leaders of women gender and it limits their chances to have advancing career in top-level positions.

RESEARCH METHODOLOGY

Objectives of study
- o To investigate if there is existence of any kind of differences in the way men and women communicate at the workplace
- o To examine the various approaches adopted by different genders at workplace
- o To examine the structure of behavior of employees at workplace based on their gender

Source of Data
- o Primary source by the way of administering a structured questionnaire.
- o Secondary source from the Journals, Websites and Portals.

Research Design
It is a descriptive research design. Convenience sampling method has been used for this study. Data has been collected using structured online questionnaire. The sample size is comprised of 70 IT professionals in 1:1 ratio of men and women.

Research Questions
1. Is there a difference in the approach adopted by different genders at workplace?
2. Is there a difference in the structure of behavior of employees at workplace based on their gender?
3. Is there a difference in the way men and women communicate at workplace?

Techniques of Analysis
Study is based on primary and secondary data. Primary data is collected through structured questionnaire. Data collected is analyzed graphically and statistically with the use of various statistical tools.

ANALYSIS & FINDINGS

Table 1. Descriptive Statistics of Respondents

Demographic Variable	Percentage
Gender	
Men	50%
Women	50%
Age	
Under 20	0
20-30	62.9%
30-40	34.3%
40-50	2.8%
50 & above	0
Marital Status	
Never married/Single	44.3%
Married	51.4%
Divorced	4.3%
Widowed	0

The above table shows that maximum respondents are from age-group 20-30 and are married, followed by respondents from the age-group 30-40 and never married/single.

Graphical Analysis:

Figure 1. Classification of respondents based on preferable medium of interaction
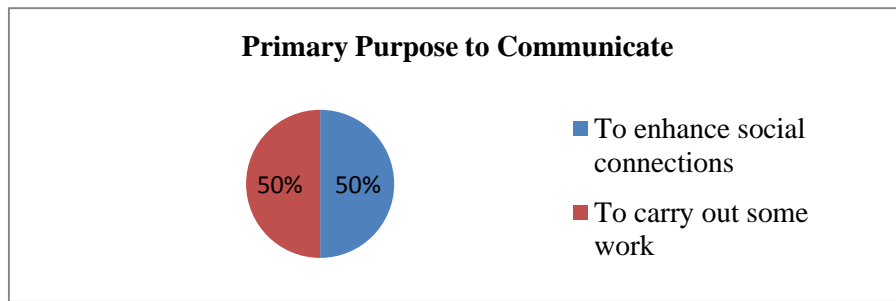
Table 2.

Preferable medium of interaction

- Over phone — 32%
- Face-to-face — 37%
- Both — 31%
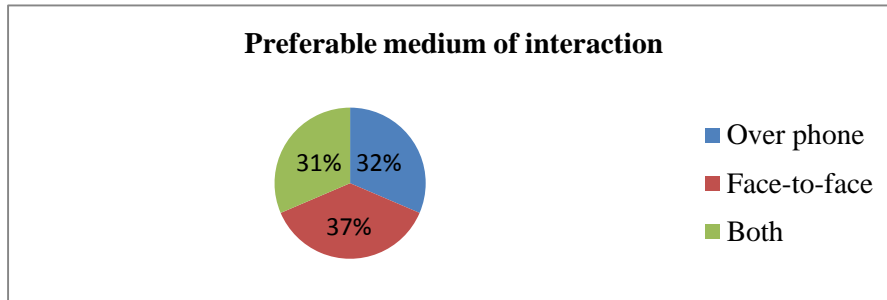
Classification of respondents based on preferable medium of interaction

Preferable medium of interaction	Men	Women
Over Phone	4	18
Face-to-face	20	6
Both (Depends on requirement)	11	11

The above graph and table shows that men usually prefer face-to-face communication more while women go for over phone as women are more comfortable on phone conversations for a long period of time as women use phone to talk to their friends and relatives for longer periods.

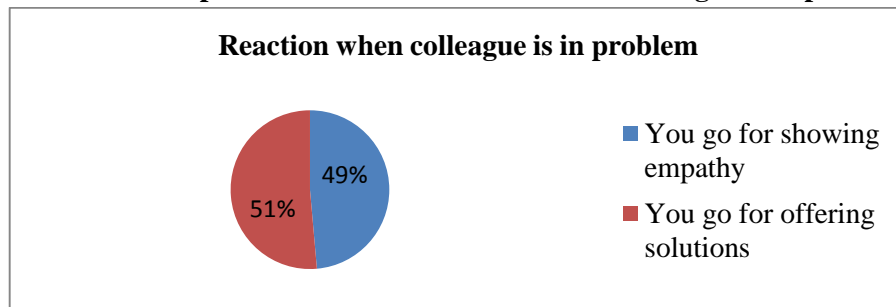**Figure 2. Classification of respondents based on their primary purpose to communicate**

Primary Purpose to Communicate

- 50% To enhance social connections
- 50% To carry out some work

Table 3. Classification of respondents based on their primary purpose to communicate

Primary purpose to communicate	Men	Women
To enhance social connections	2	33
To carry out some work	33	2

The above graph and table shows that for men, primary purpose to communicate is to carry out some work while for women it is to enhance social connections. This might be because of the reason that men are goal-oriented while women are relationship-oriented.

Figure 3. Classification of respondents based on reaction when colleague is in problem


Reaction when colleague is in problem

- 49% You go for showing empathy
- 51% You go for offering solutions

Table 4. Classification of respondents based on reaction when colleague is in problem

| What you usually do when your colleague is in problem	Men	Women
You go for showing empathy & understanding their problems	1	33
You go for offering probable solutions for their issues	34	2

The above graph and table shows that men are more of direct and hence they go for offering solutions when any of his colleague is in problem. But, women are indirect in nature and they go for showing empathy to her colleague for the same situation. Because of the reason that men use instrumental style to communicate while women, uses expressive style.

Classification of respondents based on agreeableness regarding statements relating to approaches of genders

Figure 4.1 - Men
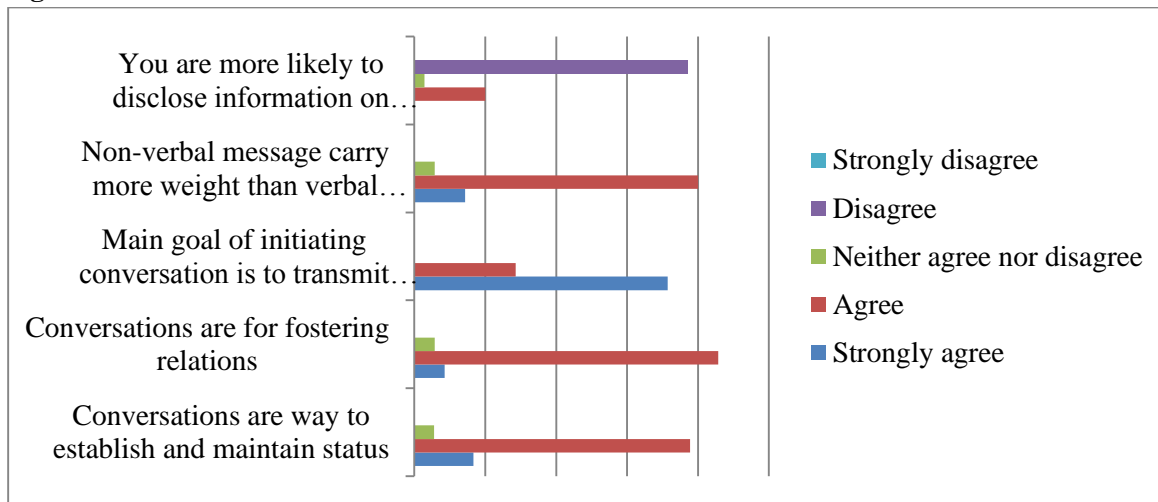
Figure 4.2 - Women
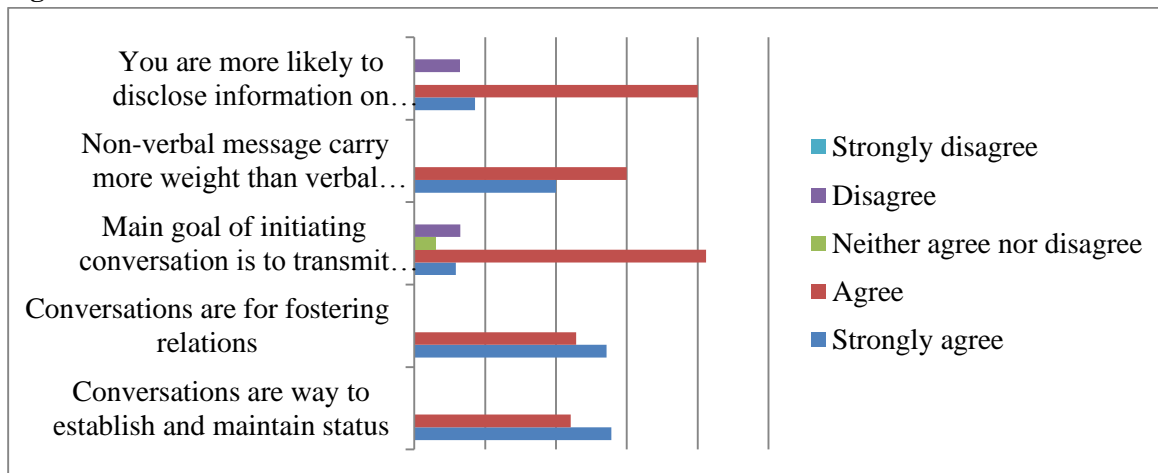
Above two charts draws different conclusions, women strongly agrees to the statement that conversations are for fostering relations, non-verbal message carry more weight than verbal message and you are more likely to disclose information on personal concerns compared to men. While, men strongly agrees to the statement that main goal of initiating conversation is to transmit information and conversations are way to establish and maintain status. This shows that men are more power-hungry compared to women. While, women pays more attention to non-verbal cues unlike men.

Cross-Tabulation:

Table 5: Cross Tabulation of age and preferable medium of interaction

Age/Preferable medium	Over Phone	Face-to-face	Both (Depends on situation)
Under 20	0	0	0
20-30	16	12	16
30-40	6	13	5
40-50	0	1	1
50 & Above	0	0	0

From the cross tabulation of age and preferable medium of interaction, it is observed that respondents from age group 20-30 prefer more of over phone as preferable medium of interaction, while respondents from the age-group 30-40 prefer more face-to-face interaction. Here, it can be inferred that young people nowadays find phone as the easy and preferable way over any other medium.

Table 6: Cross Tabulation of age and primary purpose to communicate

Age/Primary purpose to communicate	To carry out work	To enhance social connections
Under 20	0	0
20-30	20	24
30-40	13	11
40-50	2	0
50 & Above	0	0

From the cross tabulation of age and primary purpose to communicate, it is observed that respondents from the age group 20-30 considers enhancing social connections as the primary purpose to communicate while, respondents from the age group 30-40 says they prefer that primary purpose of communication is to carry out a particular task. Here, it can be inferred that younger generation started taking enhancing social connections as the best base to carry out work.

Test of Normality:

Hypothesis

H_0: The Distribution is normally distributed.

H_1: The Distribution is not normally distributed.

Figure 5.1: Test of Normality

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Approach	.369	70	.000	.632	70	.000
Behaviour	.347	70	.000	.636	70	.000

a. Lilliefors Significance Correction

Figure 5.2: Test of Normality

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Maintain_Status	.375	70	.000	.694	70	.000
Fostering_Relations	.396	70	.000	.679	70	.000
Transit_Information	.305	70	.000	.722	70	.000
People_Interaction	.286	70	.000	.759	70	.000
Nonverbal_Message	.417	70	.000	.656	70	.000
Openness	.409	70	.000	.670	70	.000
Personal_concerns	.334	70	.000	.744	70	.000
Personal_space	.238	70	.000	.860	70	.000
Answer_Questions_ Addressed_to_you	.216	70	.000	.866	70	.000

a. Lilliefors Significance Correction

Both the tests are having significance two-tailed value less than 0.05. Hence, Ho can be rejected at 5 percent level of significance. All the factors are not found normally distributed at 5 per cent level of significance. Hence, it would be appropriate to perform non-parametric test on these factors.

Non-Parametric Tests:

1) **Approach:** To assess the difference in the approach adopted by men and women at workplace, Mann-Whitney U Test is performed depending on the number of independent groups.

    H0: There is no significance difference in the approach adopted by men and women at workplace

| | | **Figure 6.1: Ranks** | | | | **Figure 6.2: Test Statistics** |

Ranks

	Gender	N	Mean Rank	Sum of Ranks
Approach	Men	35	20.00	700.00
	Women	35	51.00	1785.00
	Total	70		

Test Statistics^a

	Behaviour
Mann-Whitney U	52.500
Wilcoxon W	682.500
Z	-7.598
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Gender

Figure 6.1 above shows the mean rank and sum of ranks of Approach adopted by men and women. In the second figure, the calculated Mann- Whitney U, degree of freedom, and significance value is given. It can be observed that the significance two-tailed p value is less than 0.05. Hence, Ho can be rejected at 5 percent level of significance. Hence, it can be concluded that, there is a significance difference in the approach adopted by men and women at workplace.

2) **Structure of Behaviour:** To assess the difference in the structure of behaviour between men and women at workplace, Mann-Whitney U Test is performed depending on the number of independent groups.
H0: There is no significance difference in the structure of behaviour between men and women at workplace

Figure 7.1: Ranks   **Figure 7.2: Test Statistics**

Ranks

	Gender	N	Mean Rank	Sum of Ranks
Behaviour	Men	35	51.50	1802.50
	Women	35	19.50	682.50
	Total	70		

Test Statistics^a

	Approach
Mann-Whitney U	70.000
Wilcoxon W	700.000
Z	-7.406
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Gender

Figure 7.1 above shows the mean rank and sum of ranks of structure of behaviour between men and women. In the second figure, the calculated Mann- Whitney U, degree of freedom, and significance value is given. It can be observed that the significance two-tailed p value is less than 0.05. Hence, Ho can be rejected at 5 percent level of significance. Hence, it can be concluded that, there is a significance difference in the structure of behaviour between men and women at workplace.

3) **Communication:** To assess the difference in the way men and women communicate at workplace, Mann-Whitney U Test is performed depending on the number of independent groups.
H0: There is no significance difference in the way men and women communicate at workplace

Figure 8.1: Ranks

Ranks

	Gender	N	Mean Rank	Sum of Ranks
Attention_To_Speaker	Male	35	35.00	1225.00
	Female	35	36.00	1260.00
	Total	70		
Maintain_Status	Male	35	28.54	999.00
	Female	35	42.46	1486.00
	Total	70		
Fostering_Relations	Male	35	27.04	946.50
	Female	35	43.96	1538.50
	Total	70		
Transit_Information	Male	35	46.43	1625.00
	Female	35	24.57	860.00
	Total	70		
People_Interaction	Male	35	24.23	848.00
	Female	35	46.77	1637.00
	Total	70		
Nonverbal_Message	Male	35	30.40	1064.00
	Female	35	40.60	1421.00
	Total	70		
Openness	Male	35	34.09	1193.00
	Female	35	36.91	1292.00
	Total	70		
Personal_concerns	Male	35	21.41	749.50
	Female	35	49.59	1735.50
	Total	70		
Personal_space	Male	35	27.39	958.50
	Female	35	43.61	1526.50
	Total	70		
Answer_Questions_Addressed_to_you	Male	35	31.57	1105.00
	Female	35	39.43	1380.00
	Total	70		

Figure 8.2: Test Statistics

Test Statistics[a]

	Attention_To_ Speaker	Maintain_ Status	Fostering_ Relations	Transit_ Information	People_ Interaction	Nonverbal_ Message	Openness	Personal_ concerns	Personal_ space	Answer_ Questions_ Addressed_ to_you
Mann-Whitney U	595.000	369.000	316.500	230.000	218.000	434.000	563.000	119.500	328.500	475.000
Wilcoxon W	1225.000	999.000	946.500	860.000	848.000	1064.000	1193.000	749.500	958.500	1105.000
Z	-.277	-3.364	-4.200	-5.123	-5.155	-2.627	-.749	-6.432	-3.582	-1.695
Asymp. Sig. (2-tailed)	.782	.001	.000	.000	.000	.009	.454	.000	.000	.090

a. Grouping Variable: Gender

Figure 8.1 above shows the mean rank and sum of ranks of communication factors between men and women. In the second figure, the calculated Mann- Whitney U, degree of freedom, and significance value is given. It can be observed that the significance two-tailed p value is less than 0.05 for all the factors except three factors namely "Attention to Speaker", "Openness" and "Answering Questions Addressed to you". Hence, Ho can be rejected at 5 percent level of significance for other factors except those three factors. Hence, it can be concluded that, there is a significance difference in the structure of behaviour between men and women at workplace.

CONCLUSION

Through the analysis above, we get idea about the gender and communication patterns. Gender communication and differences in the workplace abound. Gender differences in communication is not about right or wrong, it is just about adopting the styles of each other in a way that increases the productivity of organization and that avoids any kind of inadequate communication. Psychological differences between genders often depicts women's administration abilities and capacities in a negative light, thus find it hard making achievement in top level positions. At last, powerful relational abilities provide innovative ideas, optimistic feedback, motivation thereby improves association between managerial staff and employees.

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ESTIMATION OF MOTORCYCLE UNITS FOR MOTORCYCLE DOMINATED TRAFFIC: A CASE STUDY OF AHMEDABAD

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ABSTRACT

India, just like many south Asian countries, is an emerging economy. The traffic in Indian urban areas is of 'heterogeneous' nature with 2-wheeler vehicles dominating the traffic flow by around 70%. Passenger Car Unit (PCU) in used commonly to convert each class of vehicles for estimating capacity of a road. But in mixed traffic condition, there is absence of lane discipline and presence of different classes of vehicles. Further, the proportion of passenger cars in the traffic stream is considerably less as compared to 2-wheeler vehicles. Therefore, the aim of this paper is suggest equivalency factors in terms of motorcycles for Ahmedabad city. Motorcycle Unit (MCU) for each class of vehicles has been estimated using speed and effective space parameters. Data collection was carried out by videography method on two urban mid-block sections in Ahmedabad city. It was found that the effective space for each vehicle increases with increase in its speed. Final MCU results were 1.54, 15.16, 3.86, 8.32, 1.00, and 2.34 for bicycle, bus, car, LCV, motorcycle, and rickshaw respectively. The values obtained from this study can be used to evaluate roadway capacity with increased accuracy for design, planning, operation, and layout of road sections. Besides, the same approach can be applied for estimation of PCUs accurately by dynamic effective space parameter.

Keywords: Mixed Traffic, Effective Space, Motorcycle Unit, Passenger Car Unit

1. INTRODUCTION

In Ahmedabad, total registrations of the two-wheeler vehicles were recorded as 1,948,844 units when opposed to cars, recorded as only 594,679; motorcycles being more than thrice the number of cars (Ahmedabad Regional Transport Office, Government of Gujarat)[1]. It has been observed that the sale of 2-wheeler vehicles is increasing every year. Reasons contributing to this are its affordability, high mileage, easy maintenance, maneuverability, etc. In general, total traffic in the Ahmedabad city comprises 70% of 2-wheeler vehicles. Therefore, it becomes irrelevant to consider 'passenger car' as a base vehicle for the calculating equivalency factors of other classes because of the dominance of 2-wheeler vehicles in traffic composition. The concept of Passenger Car Equivalent (PCE) was introduced in Highway Capacity Manual (1965), and since then, extensive research has been conducted for estimating PCE or PCU values for different traffic conditions accurately. However, PCU values are not suitable in Indian urban roads due to the heterogeneous mix of traffic, absence of lane discipline, and variations in each class of vehicles itself. Therefore, road designs might not be sufficient in urban areas when designed using these PCU values.

Traffic condition in India is very different from that of developed countries. The latter is dominated by passenger cars and can be recognized as almost homogeneous traffic, but the former is composed of different classes of vehicles, particularly in urban roads, dominated by motorcycles (a majority in

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[1] From the year 2005 to November 2020

the range of 100cc to 150cc). In this research, the category of motorcycles consists of geared bikes, electric bikes, non-geared scooters, geared scooters, and mopeds. "The wide variety of vehicles and the disparity in their size and speed create a number of problems for traffic operations. Vehicles do not respect the lane markings and tend to utilize every possible lateral or longitudinal gap" (Chandra and Kumar, 2003). The vast difference in static and dynamic characteristics of all vehicles occupying the same right of way (ROW) results in non-uniform motion of vehicles on road. Most of the studies are carried out in developed countries, and there exist fewer studies taking into account the mixed nature of traffic on Indian roads. High-performance vehicles in mixed traffic conditions are obstructed by slow-moving vehicles, resulting in a platoon of traffic with a similar speed in a cluster. Furthermore, in urban roads of Ahmedabad city, the proportion of passenger cars was comparatively less than motorcycles, which was observed from the classified volume count study conducted in the selected sites for MCU study.

It is more logical to use a motorcycle as a base vehicle considering its high proportion in mixed traffic of Ahmedabad city. The dominance of motorcycles in a traffic flow affects the traffic condition differently than passenger cars. Due to its easy maneuverability, it can slow down other classes of vehicles present in the mixed flow and their smaller size allows them to fill the gaps between other classes of vehicles causing traffic congestion. "Most motorcycles don't follow strictly the lane discipline of the road in mixed traffic flows" (Cao and Sano, 2012). The problem of measuring the traffic capacity of roads with mixed nature of traffic is often resolved by converting all classes of vehicles into an equivalent unit. Vehicle capacity of a roadway is defined as the maximum number of vehicles passing a given point on the roadway within a specific period, usually taken as one hour, under currently existing conditions. To estimate the equivalency factor of all classes of vehicles in urban areas with the dominance of motorcycles, the concept of Motorcycle Unit (MCU) is studied in this paper.

The PCU values have been estimated previously using various parameters such as speed, headway, density, etc. Chandra and Kumar (2003) adopted a model to estimate PCU with the help of mean speed and projected area. The projected area is a constant value, unlike mean speed. But space requirement for a vehicle on the road depends on the speed of the vehicle, mode, surrounding nature of traffic, driver characteristics, etc. Therefore, to estimate the more dynamic values of MCU, the effective space of vehicles were considered. Effective space is the space requirement of a vehicle to maintain its desired speed on road. Regression analysis was adopted to establish the relationship between speed and effective space for each class of vehicles.

1.1 Objectives

Following are the objectives of this research:

1. To develop a methodology for estimating MCU values for traffic in Ahmedabad city accounting for its mixed nature.
2. To establish a relationship between dynamic characteristics such as speed and effective space for different classes of vehicles.
3. To estimate MCU values of different classes of vehicles using effective area and speed.

2. METHODOLOGY

"The definition of [MCU] is the number of motorcycles that can be displaced for one vehicle of a specified type running at the speed of that vehicle" (Cao and Sano, 2012). Dynamic characteristics of the moving vehicles in mixed-traffic are taken in consideration for estimating MCU for each class of vehicles. Chandra and Kumar (2003) considered speed as the prime variable for estimation on PCU values.

$$PCU_i = \frac{V_C \,/\, V_i}{A_C \,/\, A_i} \qquad\qquad [1]$$

Where, V_c and V_i = mean speed for cars and type i vehicles respectively, and

A_c and A_i = their respective projected rectangular areas (*length ×width)* on the road.

However, the projected area in this model is constant based on average dimensions of that vehicle class, but the area occupancy is a dynamic factor affected by speed of that subject vehicle, speed of surrounding vehicles, driver characteristics etc. Therefore, effective space is considered in this study instead of projected area. Effective space is the space required by a vehicle to maintain its desired speed on road. Evidently, saturation flow is necessary for calculating effective space; on a road without saturation flow, very few samples will have motorcycles surrounding it and; hence, sufficient data cannot be collected. Effective space will be calculated as illustrated below.

Figure 1 Effective Space; Source: Vyas and Anovadia, 2021
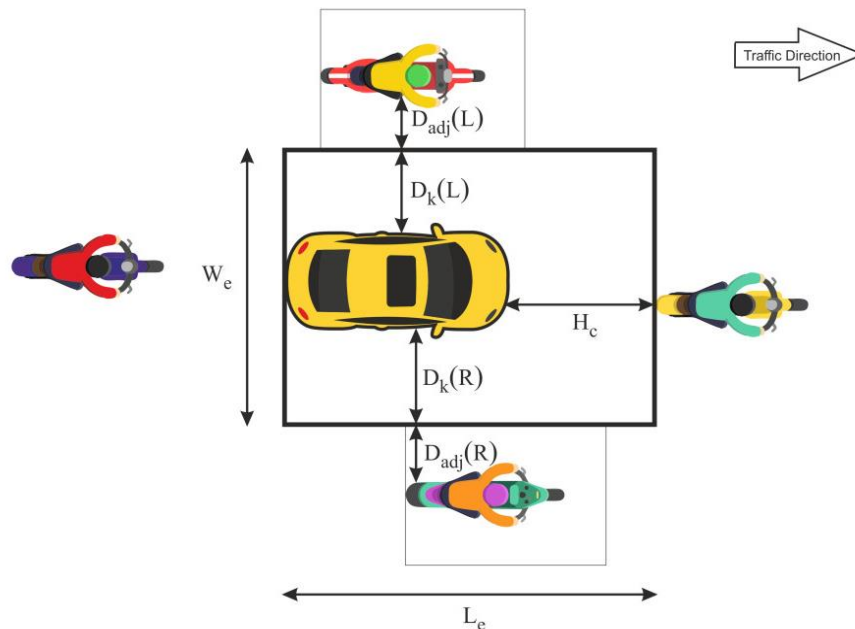
From figure 1, Effective Space= $L_e \times W_e$
Where, L_e = Effective length and W_e = Effective width.
Here, effective length can be calculated simply by addition of headway clearance to the projected length of the subject vehicle. So, L_e = projected length L + headway clearance H_c

But, there stands a problem in determining effective width for the subject vehicle. It is tricky to measure lateral clearances on both sides of the subject vehicle. Furthermore, the lateral clearances depend on the size of subject vehicle and adjacent vehicles on both sides. As assumed by Cao and Sano (2012), the lateral width of the subject vehicle is divided proportionately in accordance with a physical size ratio of the subject vehicle and adjacent vehicles and lateral width of adjacent motorcycle. Hence, the lateral clearance for the subject vehicle can be calculated as below.

$$Dk^{(R/L)} = \frac{L_k \times W_k}{L_{adj} \times W_{adj}} \times Dadj^{(R/L)} \qquad\qquad [2]$$

Where, (R/L) is for right or left.

Dk = Lateral clearance for subject vehicle k.

Dadj = Lateral clearance for adjacent vehicle (motorcycles).

L_k and W_k = Average length and average width of subject vehicle respectively.

L_{adj} and W_{adj} = Average length and average width of adjacent vehicles respectively.

Average length and width of various vehicle classes have been adopted from Chandra and Kumar (2003) because they are very accurate with respect to Indian traffic and also widely adopted in studies of various developing economies.

Table 1: Average Dimensions of considered vehicle classes

	Vehicle Classes	Average Length (m)	Average Width (m)
1	Bicycle	1.9	0.45
2	Bus	10.1	2.43
3	Car	3.72	1.44
4	LCV	6.1	2.1
5	Motorcycle	1.87	0.64
6	Rickshaw	2.7	0.95

Source: Chandra and Kumar, 2003

From the figure 1,

$$W_e = Dk(L) + W_k + Dk(R) \qquad [3]$$

From the table 1 and equation [3], we can calculate effective width, and finally obtain effective space for a subject vehicle. After calculating effective spaces for each sample we need to estimate MCU values using dynamic characteristics i.e. speeds and effective spaces for each class of vehicles. The equation [1] for estimating PCU, as mentioned earlier is modified as below:

$$MCU_k = \frac{V_{mc} / V_k}{Ae_{mc} / Ae_k} \qquad [4]$$

Where, V_{mc} and V_k = mean speed for cars and type k vehicles respectively

Ae_{mc} and Ae_k = their respective mean effective spaces on the road

MCU_k = MCU for class k vehicle

3. LITERATURE REVIEW

Chandra and Kumar (2003) estimated the values of PCU for various classes of vehicles in mixed traffic condition in India. Mean speed and their respective projected area on ground were used in their model for estimating PCU values. It was found that the values of PCU increase linearly to the width of carriageway because narrow lanes do not provide adequate margin of error and, therefore, speed of individual vehicles drop. However, in this research, projected areas are static values and in actual scenario, the area requirement by each vehicle on road depends on several factors such as speed of subject vehicle, speed of surrounding vehicle, driver characteristics etc.

Cao et al. (2007) studied the impacts of effective space on speed of various vehicles. Effective space approach is used here instead of projected area to estimate MCU values more dynamically. Relationship between speed and effective space for each class of vehicle is established at three locations in Hanoi city, Vietnam. Videography method was employed for data collection and SEV software developed by Minh et al. (2005) was used for analysing the collected data. MCU values obtained were used to convert heterogeneous traffic stream in homogeneous equivalent. Mean stream speed was calculated in km/hr to plot speed-volume relationship.

Asaithambi and Mahesh (2016) adopted the similar methodology for urban roads in India using effective space approach. Study was conducted on mid-block sections of four-lane divided urban roads in Chennai and Mangalore. The MCU values were validated with previously developed methods. It is suggested that these values can be used for speed-flow relationship, estimation of highway capacity and formulating effective traffic control and management measures.

Cao and Sano (2012) published a paper for estimating MCU values more accurately in mixed traffic flow considering the characteristics of moving vehicles, such as velocity and effective space. Moreover, the values obtained are more accurate because they are computed by taking consideration of physical size of subject vehicles and surrounding motorcycles. It was suggested that the effective space is affected by size of subject vehicle and motorcycles on its left and right side, and hence it is assumed that lateral width of subject vehicle is a function of lateral width of motorcycles and the total physical size of subject vehicle and motorcycles. Field data were collected in Hanoi city, Vietnam by videography.

Srikanth (2019) applied space occupancy method to determine PCU values for Ongole city. To obtain the effective dimensions, the space headway of a sample vehicle was added to its physical length for effective length; however, to obtain effective width, a multiplication factor of 1.1 was multiplied with the physical width. Distinct PCU values were calculated for several speed ranges.

Vyas et al. (2021) modified the effective area approach to include the speed of adjacent motorcycles in the model to estimate effective area for each sample. The final Motorcycle Equivalent Units (MEUs) were suggested for Ahmedabad city based on data collected from two mid-block sections. These equivalency factors were recommended, for they were considered to be more accurate.

Sai Kiran and Verma (2016) reviewed various traffic studies with respect to its relevance to mixed traffic flow as found in developing economies. The ways in which traffic scenario in developing countries are different from developed countries are acknowledged. The unsynchronised movement of vehicles, absence of lane discipline, and variation in sizes and manoeuvring abilities in mixed traffic is also ascertained. This paper aims to provide review of studies on various mixed traffic characteristics in developing economies, identifying limitations and suggest future scope for research.

IRC: 106 (1990) published by The Indian Road Congress is referred to study the guidelines for capacity of urban roads in plain areas. PCU values are recommended in Table-1 for various vehicle types found in mixed traffic condition in India.

4. DATA COLLECTION AND ANALYSIS

4.1 Criteria for Site Selection

Following criteria were taken into consideration while selecting site for surveying:

- Both the ends of trap length fairly away from any intersection or diversion.
- Presence of a high building to mount video camera setup.
- Minimum obstruction to traffic flow due to speed breakers, parking, bus stops etc.
- Major urban road with high traffic volume during peak hours.
- Considerably mixed traffic with adequate proportion of motorcycles.
- Saturation flow during peak hour.

4.2 Selected Sites

1. Gulbai Tekra (Panjarapol Char Rasta- L.D. College of Engineering)

2. Kalupur Road (Kalupur Railway Station- Kalupur Darwaja)

Videography survey was conducted at both locations to record the data for further analysis. First survey was conducted on 3rd September 2020, 8:30 A.M. to 10:30 A.M. (2 hours). Second survey was conducted on 30th September 2020, 5:30 P.M. to 8:00 P.M. (2.5 hours). Video recording was started just before peak hours and was recorded for some time after peak hour. Peak hours were identified by the traffic volume studies.

Figure 2 Videography at Gulbai Tekra   *Figure 3 Videography at Kalupur Road*

4.3 Data Collection and Extraction

All the traffic data was collected by videography method on selected locations. Videos were recorded on working days in dry weather condition to study the peak hour flow with maximum traffic. The traffic volume was measured for the interval of every 15 minutes and charts for traffic composition were worked out from the data of both survey location.

Gulbai Tekra will be addressed as location-1 and Kalupur Road will be addressed as location-2 in our study.Location-1 was a 6-lane road divided by 2-lanes of exclusive bus lane with median separations and location-2 was a 2-lane one way road with additional parallel parking space on either side. Figure 2 depicts the traffic composition at both study locations.

Video camera was mounted on a tripod on top of the buildings with the camera tilted downward towards road and necessary measurements were taken on road for trap length and four base points. 25m trap length was recorded in videos. Recorded videos were later converted in AVI format in order to play it in Speed Estimation from Video Data (SEV) software. In SEV software, the base points were established and speed data was extracted simultaneously to the position co-ordinates of sample vehicles. Speeds and effective spaces were calculated and recorded in a spreadsheet to plot the relationship for speeds and effective spaces for each class of vehicles. It must be noted that only those samples were examined in this study which were surrounded by motorcycles considering the motorcycle dominated traffic and uniformity in measuring effective spaces. Finally, regression analysis was used to obtain a non-linear equation for relation of speeds and effective spaces and to find the coefficient of determination for the same.

Figure 4 Traffic Composition at locations 1 and 2 respectively
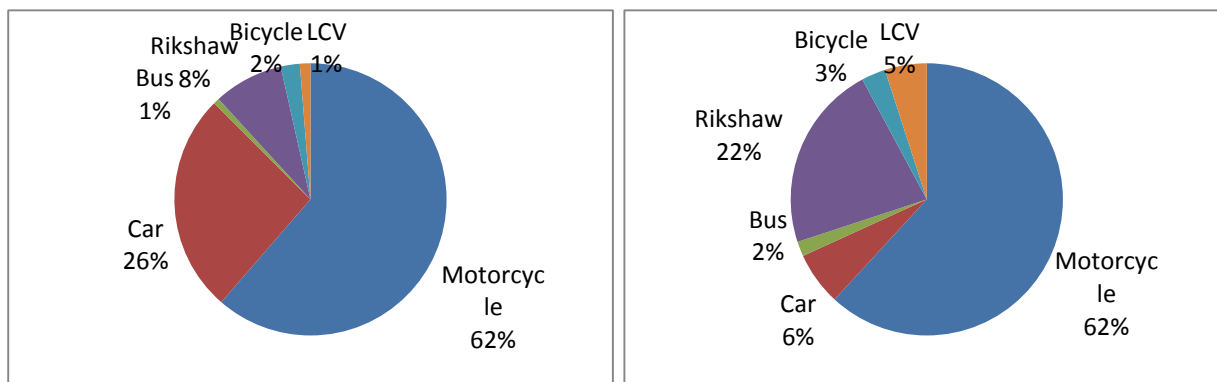
SEV software (figure 5) gives readings for speed for each vehicle by right clicking on the sample vehicle. In addition, SEV software easily converts screen co-ordinates into roadway co-ordinates, which are useful in calculating effective space around subject vehicle. A reading can be measured several times and, hence; it can be verified. The speed of each sample vehicle was calculated at 0.5 sec interval.

Figure 5 SEV Software Interface
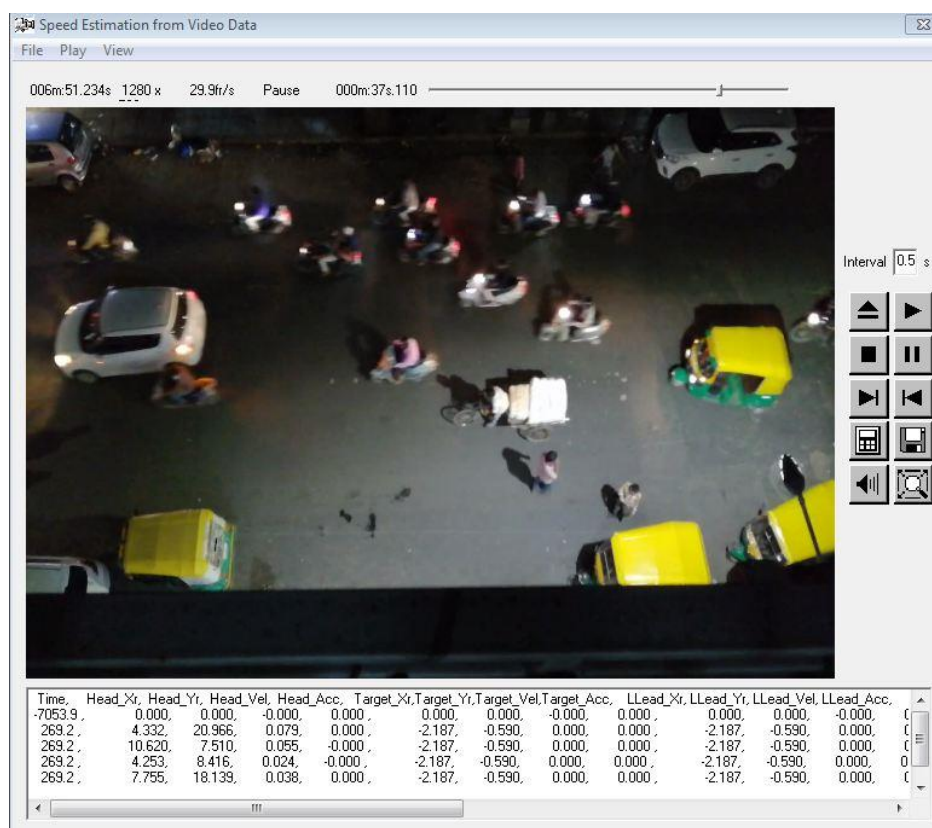
Traffic in Ahmedabad city is of mixed nature; it is important to identify all the classes of vehicles present at the study location in considerable proportion. Hence, the following classes of vehicles were selected after classified volume study and only those classes were considered for analysis from video data.

Table 2: Vehicle classes considered

	Vehicle Classes	Types Included
1	Bicycle	Bicycles
2	Bus	Buses
3	Car	Cars, Jeep
4	LCV	Tempos, Transit Mixer, Mini-buses
5	Motorcycle	Motorbikes, Scooters, Mopeds
6	Rickshaw	Rickshaws

5. DATA ANALYSIS AND RESULTS

Data for speeds and effective spaces were obtained from SEV software and were recorded in a spreadsheet. These values were then plotted on charts for each vehicle class separately as shown below. Charts for both locations are illustrated distinctively on the same graph. A non-linear line of regression is also obtained in each chart to show a positive increase in effective spaces with increase in speed of vehicles. A value of non-linear equation in the form of '$y = ax^2 + bx + c$' and the coefficient of determination (R^2) is in each graphs for both locations, where y = mean effective space of class 'k' in (m^2); x = mean speed of class 'k' in (m/s); a, b & c are constants of that non-linear function.

Figure 6 Relation between speeds and effective spaces at location 1 and 2 for Bicycle
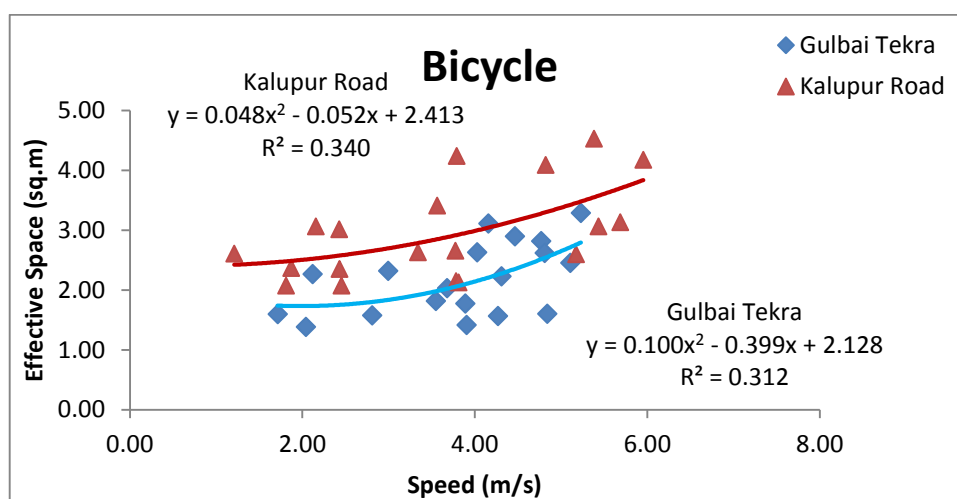
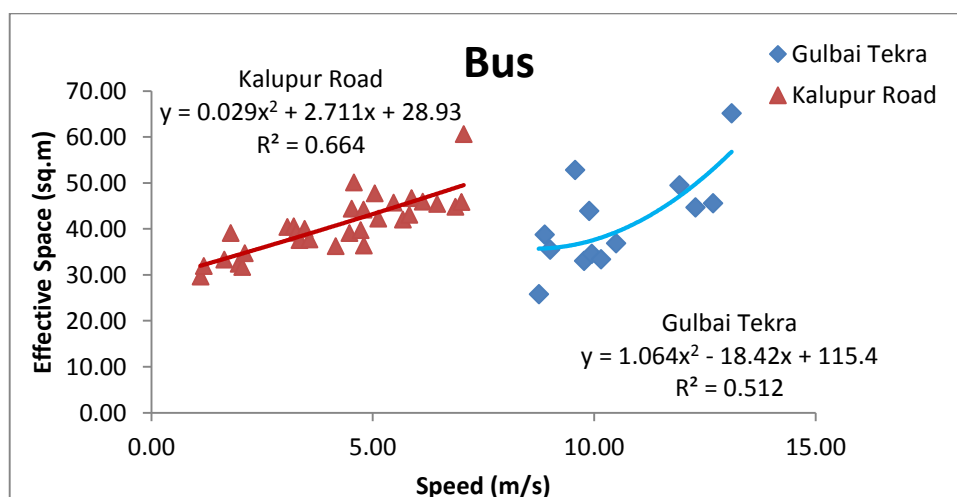*Figure 7 Relation between speeds and effective spaces at location 1 and 2 for Bus*

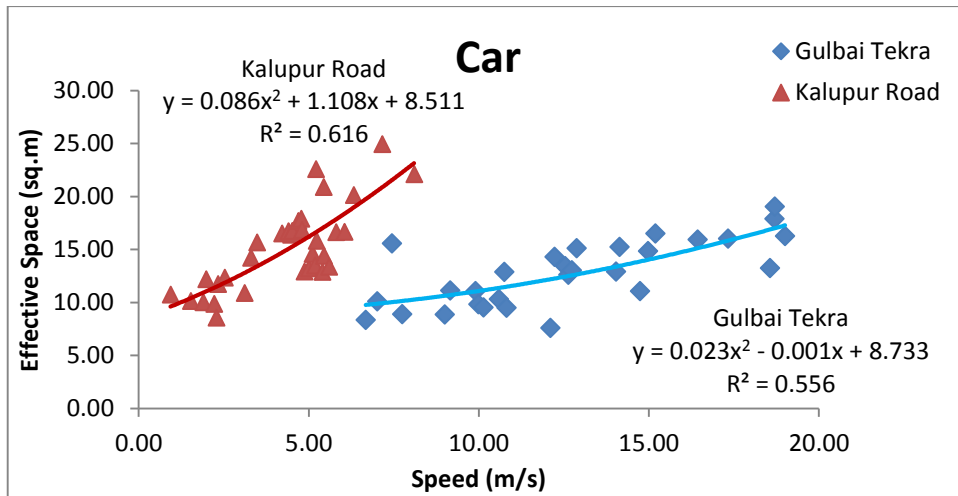*Figure 8 Relation between speeds and effective spaces at location 1 and 2 for Car*

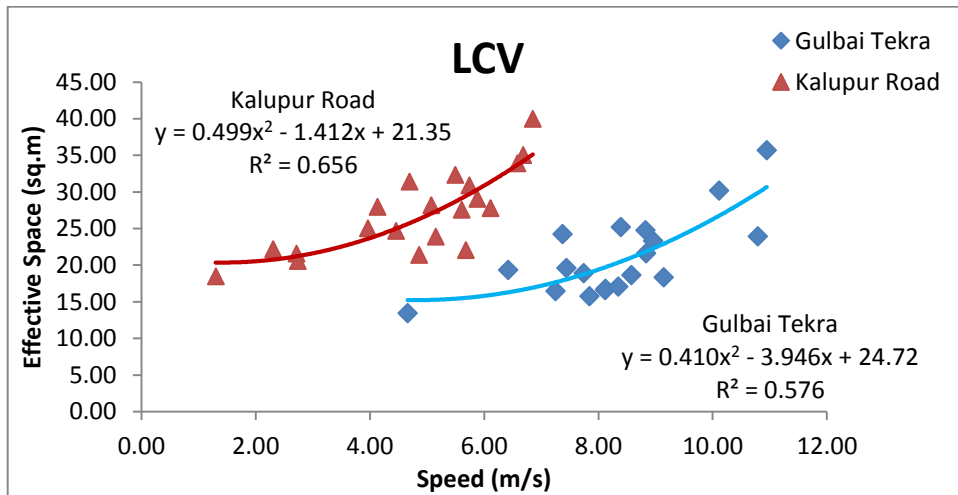*Figure 9 Relation between speeds and effective spaces at location 1 and 2 for LCV*

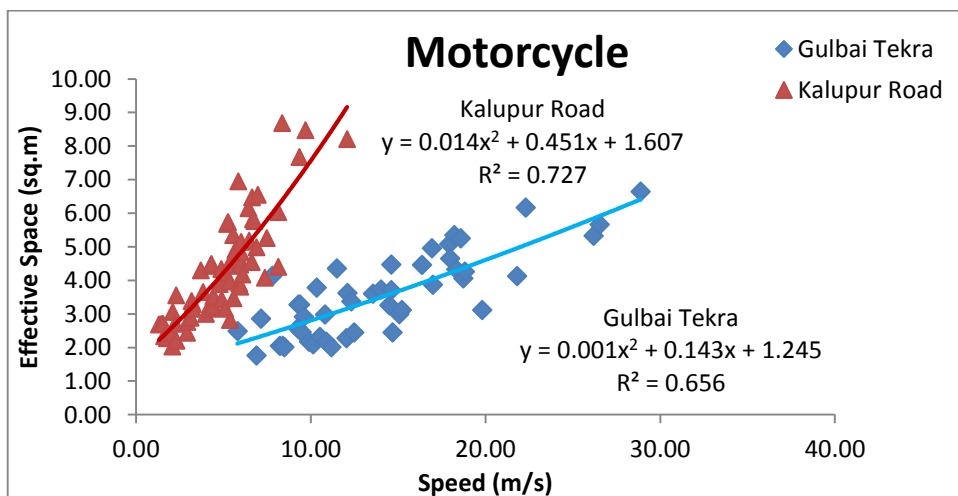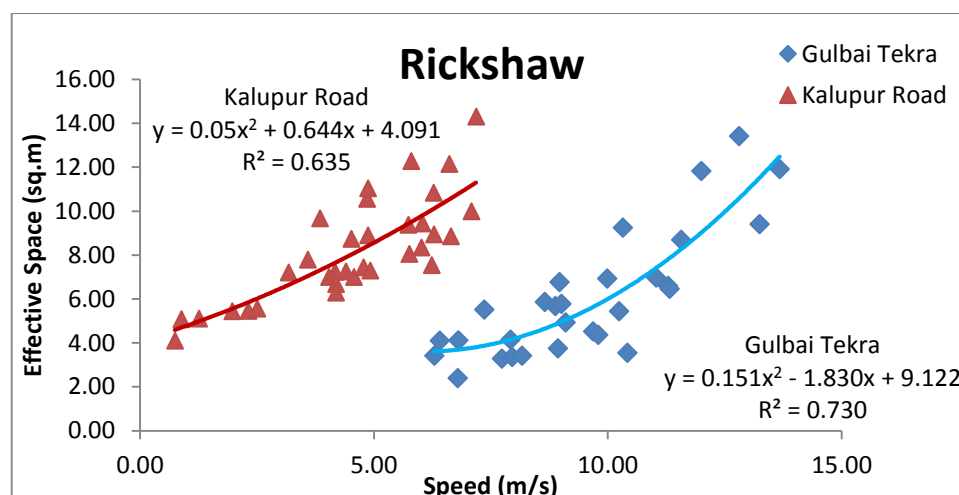*Figure 10 Relation between speeds and effective spaces at location 1 and 2 for Motorcycle*

Figure 11 Relation between speeds and effective spaces at location 1 and 2 for Rickshaw

From the regression analysis for both the locations (figure 6, 7, 8, 9, 10, and 11), it can be clearly observed that there is a high R^2 value, except for bicycles. Therefore, it can be suggested that effective space of subject vehicle is affected significantly by its speed and it increases with the speed of the vehicle. On the contrary, in case of bicycles, the R^2 values at locations 1 and 2 are 0.312 and 0.340 respectively. This is because bicycles are slow moving vehicles and usually run on the outermost side near kerbs/footpath. They are not much affected by motorcycles or any other class because drivers of other classes of vehicles usually prefer to drive close to median at higher speeds.

Furthermore, Cao and Sano (2012) studied the correlation between effective space of the subject vehicle and speed of head motorcycle at 3 locations in Hanoi city, Vietnam to identify the influence of speed of head motorcycle on effective space. The R^2 values obtained were 0.23, 0.15 and 0.12. It was found that the effective space has very low effect by the speed of motorcycle in front of it. Hence, it is assumed the same in Ahmedabad city and we have studied only the effect of position of surrounding vehicles on the subject vehicle.

MCU values for all the vehicle classes considered in this study are estimated by equation [4] based on the values of speeds and effective spaces from both locations. These equivalent units are calculated for both the study locations and also a combined final value is given after integrating all the data of both study locations in the same data set; hence, final MCU values are more appropriate as to represent Ahmedabad city. Discernibly, more similar surveys can be conducted to obtain these data for mid-block sections in entirely different locations so as to determine MCU values for Ahmedabad city with increased accuracy.

Table3: Estimated MCU values

Vehicle Class	MCU 1	MCU 2	Final MCU
Bicycle	2.26	0.95	1.54
Bus	15.70	11.36	15.16
Car	4.03	4.08	3.86
LCV	10.07	6.61	8.32
Motorcycle	1.00	1.00	1.00
Rickshaw	2.53	2.10	2.34

It is interesting to observe the final MCU value of bicycle as 1.54; as is more than that of motorcycle. These can be explained by its low speed, high effective space and very poor relation between these two variables. Also, there is significant variation in MCU values of Bus and LCV at both locations. It shows that there is considerable difference between the behaviours of both classes at these two study

locations and; therefore, even more accurate value for MCU for those two classes can be determined by obtaining same data for another location and combining it to the existing dataset.

6. CONCLUSION

The basic objective of this paper is to estimate MCU values for Ahmedabad city in particular and areas with predominance of motorcycles in general by consideration of dynamic characteristics such as speeds and effective areas. The MCU values estimated can be used for calculating roadway capacity by speed-volume relationships, which are useful for design, planning, operation, and layout of urban road sections.

The MCU values obtained from this study for bicycle, bus, car, LCV, motorcycle, and rickshaw are 1.54, 15.16, 3.86, 8.32, 1, and 2.34 respectively. These values are obtained from the data of two study locations; the accuracy of these values for Ahmedabad city can be improved by addition of more data from different study locations inside the city.

Limitation of this study is regarding the accuracy of the MCU values; the values are estimated based on the data analysis through a video in software, thus, measuring various parameters to their exactness is difficult. Also, inclusion of other factors that affect the effective area of a sample vehicle should be recognised and the model can be modified further to incorporate those factors. These factors can be speeds of adjacent vehicles, driver characteristics, local conditions etc. and this can be considered as the future scope of the studies.

7. ACKNOWLEDGEMENTS

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SCOPE OF FARM ON WHEELS TECHNOLOGY FOR VERTICAL FARMING IN INDIA

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ABSTRACT

Increasing population, industrialization, and urbanization along with limited availability of natural resources have put stress on land resources for Indian agriculture. This issue can be addressed by the concept of vertical farming to grow agricultural products in structured vertical stacked layers or floors. Many types of research have been carried out for exploring the use of techniques of hydroponics, aeroponics, and aquaponics in conjunction with advanced controls. Use innovative practices in vertical farming such as solar energy, roof-top turbines, storage batteries, RWH techniques, IoT; etc. has added new dimensions of research and practices. It can be explored. However, no studies currently exist that qualify the validity of such studies for mobile farming. The purpose of this paper, therefore, is to review the existing developments in the field of vertical farming in India and to identify the concept of "Farm on Wheel" (FoW). The study also explores the advantages and disadvantages of various vertical farming methods and identifies FoW farming as a flexible, simple, and modular solution to supply farm products at door-steps.

KEYWORDS: Vertical Farming, Hydroponics, Aeroponics and Aquaponics, Farm on Wheels

1. INTRODUCTION

Growing population with limited conventional natural resources has put stress on limited lands for farming and agricultural production in India. Agriculture plays a key role in the Indian economy too. Land parcels have become expensive due to increasing urbanization and industrialization. Indian agriculture with horizontal farming involves many challenges and issues related to the requirement of huge land area, more consumption of water through conventional farming practices, excessive use of pesticides and fertilizers, flooding & drought, waterlogging and soil erosion, soil degradation, etc. However, there is an enormous scope of production potential in Indian agriculture by involving technical changes through organized research in this field. Well-designed and planned Vertical Farms are a form of controlled environment agriculture (CEA) for the growing of fruits, vegetables, biofuels, drugs, and vaccines **(Despommier D., 2014)**. Vertical Farming (VF) is structured in vertically stacked layers, vertically inclined surfaces, and/or integrated with other structures such as skyscrapers, used warehouses, or even in the shipping container and facilitates year-round cultivation.

Various organizations have researched the field of Vertical Farming in India. A vertical garden structure is developed recently by ICAR-Indian Institute of Horticultural Research, Bengaluru. This structure is user-friendly for urban and peri-urban societies to grow varieties of daily vegetables, medicinal and flower crops. The system is found to be used to meet the nutritional requirement of the family and thereby resulting in better health of society **(Rathinakumari A. C. et al., 2019)**. Central Research Institute for Jute and Allied Fibres, Barrackpore (West Bengal) explored the use of

Integrated Vertical Farming System (IVFS) to grow fodder for rearing animals and vegetables of daily use **(Singh A. K. and Das D., 2018)**.

The efforts are made to review the literature through various sources for the concept and feasibility of vertical farming and to draw conclusions regarding the future scope of technological enhancement in this field.

2. VERTICAL FARMING CLASSIFICATION

Classification according to processes used in the vertical farming system:
   a) Hydroponics (Harris, 1992).
   b) Aeroponics (Lakhiar, 2018).
   c) Aquaponics (Lennard, 2019)

Hydroponics, Aeroponics, and Aquaponics are recent techniques used for VF. Various Indian researchers have been already worked and been also looking for the feasibility of these technologies in conjunction with other advanced controls.

2.1 Hydroponics

In the Hydroponics method, the plants are cultivated in nutrient-enriched water and so here water is considered as an accountable wholesome factor for plant growth. **Harris (1977)** defined this method as "The science of growing plants using a mixture of essential plant nutrients dissolved in water and the medium other than soil." However, **Jensen (1997)** considered hydroponics as a technology for growing plants in an environment of water containing fertilizers with or without the use of mechanical support of an artificial medium like sand, gravel, etc. Word "Hydro" stands for water and "Ponos" for labour and hence in the hydroponics system the role of labor is played by water as an element.

In this method, the plant root is surrounded or circulated and submerged by a nutrient-enriched solution. The process is controlled with the essential chemical composition of plant nutrients dissolved in water. Without land, the artificial application of plant nutrients supplies all necessary elements that are usually acquired by plant roots through the root zone. In a limited space the maximum healthy yield can be achieved by maintaining an optimized microclimatic condition. The process of growing plants immersed in nutrient solution often involves inert medium sand, gravel, or any such material to support the environment mechanically. Figure 1 shows the general setup of the hydroponic system.
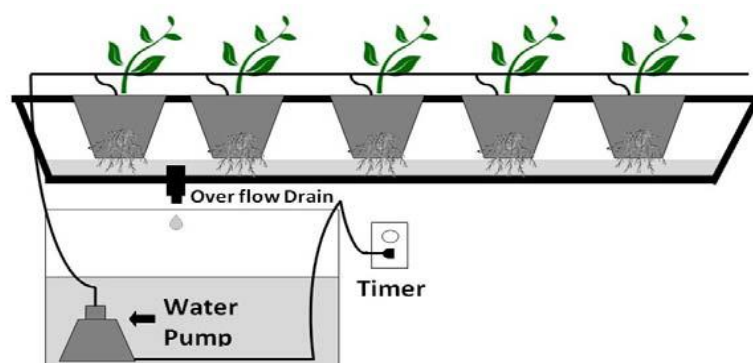
Fig.1 General Hydroponics Setup
Source: Hydroponic graphic. Illustration: NCAT

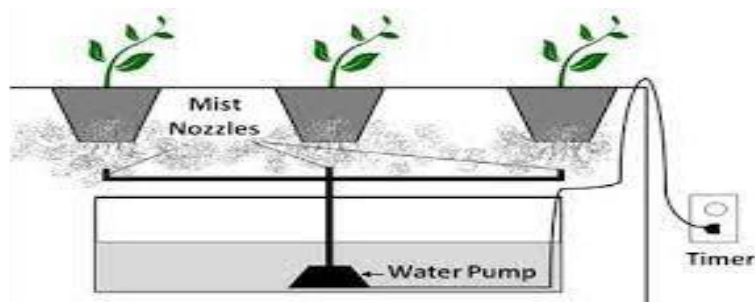*2.1.1 Advantages of Hydroponics*

- Healthy yield of crops with the composition of nutrient solution, electrical conductivity, DO, and pH levels
- Reduced use of harmful fertilizer and pesticides and thereby abolition of soil-borne diseases
- Decrease the use of fertilizers and pesticides.
- Limited space and limited water usage and so most suitable for urban areas

However, recently many researchers in India have explored the benefits of using Internet of Things (IoT) concepts in hydroponics systems to optimize the micro-climate for plant growth **(Mehra M. et al., 2018; Tembe S. et al., 2018; Pant T. et al. 2018; Bhuvaneswari P. et al., 2020; Murthy B. N. S. et al., 2016).**

2.2 AEROPONICS

Aeroponics is a type of technique in which a streamlined interaction is created for developing yields and plants in an air medium without the utilization of soil or a total medium by splashing the plant's foundations with an atomized or showered, supplement rich water arrangement.

Aeroponics is a cultivating procedure including plant development in an encased chamber by air circulation of roots through a miniature shower of watery supplement fog. This system consists of an aquaculture framework where plant establishes are suspended in air and discontinuously drenched with a supplement-rich, mineral-based arrangement. Figure 2 shows the general setup of the aeroponic system.

Fig. 2 *General Aeroponic Setup*
Source: *Aeroponic graphic. Illustration: NCAT*

2.2.1 Advantages of Aeroponics

- Aeroponics is more invaluable than the ordinary strategies of engendering for example lesser existence prerequisite.
- All year crop creation in a controlled climate (regardless of season), restricted water utilization because of reusing measure, totally natural cultivating as no need of manures and pesticides, sound (more supplement accessibility) and sickness free plants items, huge scope clonal creation for business and protection purposes, simple admittance to root framework lessening work cost in the event of root crops.

- A high-level type of aquaculture, Aeroponics is the way toward developing plants with just water and supplements. This creative strategy brings about quicker development, better plants, and greater yields all while utilizing fewer assets.

The use of Aeroponics in agriculture was proposed by researchers to establish the optimal, accurate and economical irrigation control **(Mithunesh P. et al., 2015, Suvarna G. et al., 2020, Sudharsan S. et al., 2019).**

2.3   AQUAPONICS

Investigating a record from FAO report, they discuss soil-less societies as a method of developing farming harvests without the utilization of soil. Rather than soil, different dormant developing media, additionally called substrates, are utilized. These media give plant backing and dampness maintenance. Water system frameworks are incorporated inside these media, consequently acquainting a supplement arrangement with the plants' root zones. This arrangement gives the entirety of the significant supplements for plant development. The most widely recognized strategy for soil-less culture is tank-farming, which incorporates developing plants either on a substrate or in a watery medium with uncovered roots.

Aquaponics is another word termed Hydroponics. It is being identified with the mix of both tank-farming (plant outlining) and fish cultivating with reuse of water. It can likewise be referred has organic cultivating as it doesn't contain any synthetic compost rather than that it utilizes the microorganisms and fish waste as manure through the water. Smelling salts in fish squander are separated by microbes and changed over into nitrites and afterward nitrates to be utilized as manure for the plants.

Aquaponics is a change of tank-farming coordinating recycled hydroponics (fish cultivating) with aqua-farming. Fish is filled in indoor lakes creating supplement-rich water arrangement through excreta which is the supplement wellspring of plants in vertical cultivating. The plants thus channel and clean wastewater which is reused in the lake. Figure 3 shows the general setup of the aquaponic system.
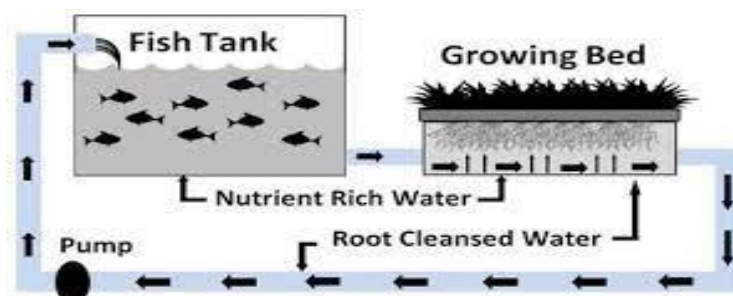
Fig.3 *General Aquaponic Setup*
Source: *Aquaponic graphic. Illustration: NCAT*

2.3.1 Advantages of Aquaponics

- Water-saving since water is re-utilized through natural filtration and distribution
- Eliminates the requirements of manufactured composts

- Efficient and financially savvy since the by-product of one organic frameworks fills in as supplements for other framework
- Provides natural fluid manures that guarantee sound development of the plants
- Cleaning water for the fish environment

As indicated by the National Ocean Service, as the interest in fish has expanded, innovation has made it conceivable to develop food in beachfront marine waters and the untamed sea. Advances in Aquaponics for farming are explored as a cost-effective and sustainable solution by various researchers **(Menon R. et al., 2013; Chavan J. et al., 2020; Surnar S. R. et al., 2017).**

Vertical farming further can be classified based on the types of structures that house the system **(Reja *et al*. 2019):**

- *Building-based vertical farms:* This type of vertical farming is often done in abandoned buildings, warehouses, etc. e.g. Chicago's 'The Plant' vertical farm.
- *Shipping container vertical farm:* Several shipping companies reject the shipping container after use which is sometimes used for vertical farming. They are furnished with LED lights, drip irrigation systems, and vertically stacked shelves for growing a variety of crops. These containers have computer-controlled growth management systems that allow users to monitor all systems remotely from a smartphone or computer e.g. Freight Farms, Crop Box, Growtainers, etc.
- *Rooftop farming:* These practices are performed from very old times for example ziggurats of ancient Mesopotamia and the Hanging Gardens of Babylon. It is simply the growing of fruits and vegetables on the rooftop. The rooftop garden is a rising trend that aims to scale up urban agriculture. The common vegetables that can be grown in rooftop gardens are carrot, radish, bean, beet, cherry tomato, and various herbs. The rooftop garden makes a distinction between a vertical garden and a vertical farm. Though both grow plants vertically the former does not always produce fruits.

3. ADVANTAGES & CHALLENGES AND FUTURE SCOPE

Many researchers have addressed various economic, environmental, and social advantages and consequent challenges for Vertical farming techniques at the global and national level **(Benke K. and Tomkins B., 2017; Kalantari F., 2018; Sonawane M. S., 2018; Sarkar A. and Majumdar M., 2015, Khalil H.I. and Wahhab K. A., 2020; Agrawal H. P. and Sinha R., 2017, Al-Kodmany K., 2018, Aswath C. et al., 2016).** A few of them are summarized herewith:

3.1 ADVANTAGES OF VERTICAL FARMING:

- More yield per unit area of land
- Crop production throughout the year
- Improve productivity against climate change and no weather-related crop failure
- Effective use of water for food production and abolishing the farm runoff
- Recycling of water and organic waste
- Reduces use of fertilizers and pesticides and thereby produces healthy organic food free from contamination
- Reduction in use of fossil fuels and conventional sources of energy using green technology like solar panels, roof-top wind turbines, and storage batteries

- Production of Energy through the generation of methane from compost
- It requires less heat than greenhouse **(Bambara J. and Athienitis A., 2015)**
- Increase in profit due to reduced use of fertilizers, herbicides, or pesticides and even due to no soil preparation required in case of hydroponics and aquaponics
- Start-ups and Employment opportunities in various fields
- Reuse of unused properties/ Shelters close to consumers
- Restore ecosystem functions and services by returning farmland to nature
- Bringing morality and understanding for conserving nature

3.2 CHALLENGES IN VERTICAL FARMING

- High start-up costs and huge investments for Land and building infrastructure in urban areas
- High operation cost due to use of energy
- Vertical farming may be suitable for growing an only limited number of species of green leafy vegetables, fruits, herbs, pharmaceutical plants
- Less acceptance to new farming technology and so alterations to traditional farming practices
- Different crops require different climatological conditions and environmental requirements and so there is a limitation to maintain such variations in a single vertical farm.
- Availability of solar radiation may not be uniform at different levels of VF.
- Cost may increase due to the requirement of skilled labours and workforce, energy management, and operation & maintenance. It is very complex and expensive to make changes and modifications in the design of the infrastructure of VF as per the requirements of the crops. However, natural process like cross-pollination is to be managed manually rather than insect pollination which may increase the additional cost of labour. Maintenance of equipment used for maintaining radiations, humidity, and other microenvironments may cost additionally.
- Cost of transporting and storing the crop yields may increase the additional requirements of infrastructure.

3.3 FUTURE SCOPE AND THRUST IN INDIA

- It is essential to integrate VF technologies with conventional and local farming practices.
- Towns, CBDs, and smart cities can be planned and designed to integrate portable Vertical Farms to supply food at a local level.
- A portable, cost-effective, and user-friendly design of Vertical Farms on Wheels can be explored and in conjunction with advanced green technologies to increase the adaptability and reduce the initial cost of investments.
- Use of local solar power to compensate energy demands, Rain Water Harvesting (RWH) and recycling of used water to address water demands, and provision of natural micro-environment at all levels of Vertical Farms are major concerns.
- The concept of "Farm on Wheels" shall be explored to boost start-ups and to supply farm products at door-steps
- Return of Investment (ROI) for various types of crops and varying levels and sizes of vertical farms can be assessed.

4. FARM On WHEELS (FoW)

Very few researchers have noticed the usefulness and scope of FoW technologies **(Horton R. P., 2017, Seo S., 2018, http://www.truckfarm.org/)**. Few case studies are represented and described herewith. Figure 4 represents a mobile solar-powered urban farm designed by The Seoul, Korea Branch of the Beijing-based the People's Industrial Design Office. The farm consists of hydroponic vessels interconnected by tubes mounted on a metal base and supported by a pair of bicycles. The energy the demand of irrigation pump is supplied through arrays of solar panels installed on the steel frame.
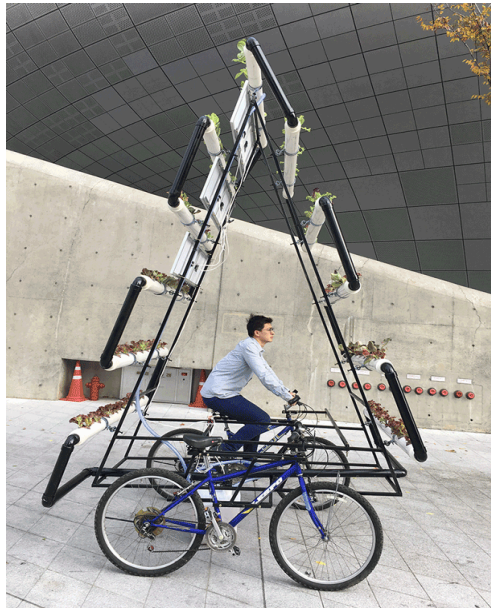
Fig. 4 *Solar-Powered Shared Bike Farm*
Source: *https://www.urbangardensweb.com/*

Moving Farms can be devised to combine production, processing, and distribution. However, these farms can move the residential areas and can provide service at door-step. Seo S., a transportation designer (2018) proposed a moving farm design to serve the significant diet supply of Shanghai. Figure 5 represents the suggested design of moving farm.

Fig. 5 *Moving Farm: Urban Vertical Farm for Shanghai in 2030*
Source: *www.michelinchallengedesign.com (2018: Mobility/Utility/Flexibility)*

Sparks R. E. et al. (2018) designed the mobile, flexible, modular, simple, and efficient Modified Hydroponic Shipping Containers (MHSC) and tested for Nutrient Film Technique (NFT) hydroponics system. With such innovative practice, authors noticed more than 50% reductions in energy consumptions with increased crop production efficiency. Figure 6 shows experimental setup showing use of NFT for crop production.

Fig. 6 *NFT prototype production system at harvesting stage*
Source: *Sparks R. E. and Stwalley R. M. 2018*

Arka Vertical Garden Structure designed by IIHR is represented in Figure 5. Aforementioned this structure can grow varieties of crops at a reasonable cost. This structure is user-friendly, portable, and mobile. However, such a structure can fulfill the daily vegetable requirements and even accommodates in a small space. Figure 7 represents the Arka vertical garden structure designed by IIHR.

Fig. 7 *Arka vertical garden structure*
Source:*https://www.iihr.res.in/arka-vertical-garden-structure*

4.1 ADVANTAGES OF FARM ON WHEELS

- The FoW has the potential to reduce the transport costs and CO_2 emissions and it reduces the spoilage of crops that occurs over a long distance.
- No need of constructing any building and other infrastructure and so no high initial investments
- Multiple crops at multiple levels using any method of vertical farming
- Qualitative supply of vegetable salads, fresh juices, and Ayurveda drinks (popular name: Kaadha) at door-steps
- A cost-effective Farm on Wheel can be integrated with Solar Source for energy and equipped with water conservation and recycling techniques for its optimum use.

- Use of limited levels with the customized area can be flexibly moved and revolved to get required sunlight and wind conditions.
- Easy to fabricate and no skilled force is required.
- Increases employability and promotes start-ups
- It can be mounted on a battery-operated vehicle with the installation of a solar panel at the rooftop.
- Suitable for any topography

5. CONCLUSION

Vertical farming is a relatively new phenomenon in India. Acceptance and adaption of this farming system at the regional level is a need of the hour to meet the growing food demand. This future demand can be addressed by constructing Vertical Farms in an open urban space. Various conventional methods used for Vertical farms have their pros and cons. However, the use of advanced technologies and innovations can be experimented with and embedded with conventional methods to optimize the use of both energy and resources and thereby increase the ROI.

Farm on Wheels is a method of farming that constitutes all key advantages of vertical farming with limited levels of farming. It offers flexibility to serve the farm and farm products at the door-steps of the customer. With little initial investment, this concept is good potential for start-up and self-sustainability. With the reduced cost of transportation, it can nurture environmental benefits to future cities.

State and Central Governments, Urban Planners, Policymakers, and entrepreneurs can associate together to promote and build such land conserving and citizen-centric sustainable Vertical Farming environments in India.

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