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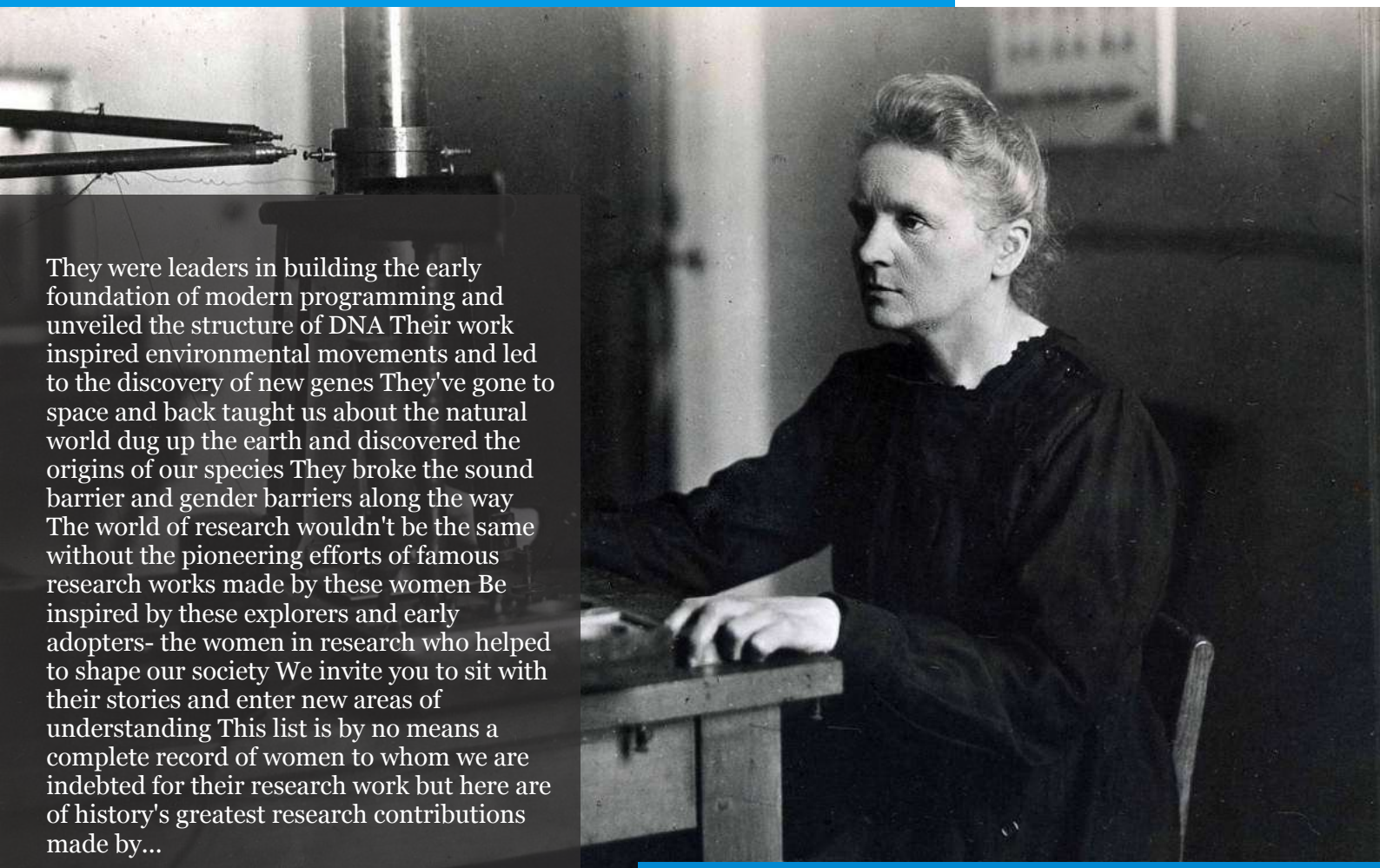

They were leaders in building the early foundation of modern programming and unveiled the structure of DNA Their work inspired environmental movements and led to the discovery of new genes They've gone to space and back taught us about the natural world dug up the earth and discovered the origins of our species They broke the sound barrier and gender barriers along the way The world of research wouldn't be the same without the pioneering efforts of famous research works made by these women Be inspired by these explorers and early adopters- the women in research who helped to shape our society We invite you to sit with their stories and enter new areas of understanding This list is by no means a complete record of women to whom we are indebted for their research work but here are of history's greatest research contributions made by...

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Dr. Wafa Qadadeh & Dr. Vinayak Mysore

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HR Analytics to Understand Employees' Behavior against HR Policies Changes in the UAE

Dr. Wafa Qadadeh[α] & Dr. Vinayak Mysore[σ]

ABSTRACT

Data analytics has been an emerging topic in the past decade. The recent literature has shown that there is a gap in the Human Resources (HR) Data Analytics in general. We intend in this research to address the absence of HR Data Analytics in the government of the UAE. The gap is broader when trying to study the consequences of HR law and policy change using the HR data analytics. In this paper, we are trying to understand how changes in HR policies can affect employees' performance. The empirical study we are proposing shows how HR analytics could help HR policies maker to investigate the effect of policies changes on employees' behavior.

The study also helps the decision makers to take data driven decisions. The statistical results presented in this research have shown that there is an effect of HR policy changes on employees' behavior. Changing the annual leave balance on a particular set of employees has affected the behavior of employees by extensive usage of other types of alternate leaves that they can avail.

Keywords: data analytics, hr analytics, people analytics, hr policies changes, employee's behavior.

I. INTRODUCTION

The past few years have witnessed a rapid growth in data analytics and its applications. The exponential increase of the data collected from different sources prepared the data analytics to be an emerging domain [1]. Human Resources (HR) and its Management Systems (HRMS) is one of the common data sources for data analytics especially in the public sector. HR Analytics or People Analytics recently has proved that it helps organizations to explore the potentials of their human capital and pro-act to resolve their challenges. This growth also arises from the use of data science and advanced data analytics to visualize complex data. This HR data would cover the employee data as individual, as a team member, and as part of an organization to provide knowledgeable insights and decisions [2]. The quality of HR is critical for organization to sustain competing within information and knowledge era [2].

There is insufficient number of empirical studies addressing HR analytics. Only 16% of organizations use HR Analytics for reporting, because of which, HR Analytics is considered as an innovation source for organizations [4]. The role of HR practices and laws have extensively been addressed in many studies and their importance were acknowledged. Nevertheless, these kinds of studies are not yet common in the public sector [5]. Al-Ayed (2019) claimed that there are many studies which addressed the organizational flexibility in different dimensions.

However, there are only a few researchers who handled the impact of human resource practices or policies on the employee's flexibility. These few studies claimed that human resource analytics would develop organization's ability to adapt and sustain [6]. Other studies such as Munshi (2019) also highlighted the gap of empirical analysis to examine the impact of human resources policies on public organizations. Munshi's (2019) study covered the women engagement issue in the Indian army and the effect of HR policies changes on this dimension [7]. While Baruch and Forstenlechner (2017) in their study conducted a qualitative approach, using interviews with United Arab Emirates (UAE) expats from different domains. The study covered the motives behind expatriation in the UAE. Baruch and Forstenlechner (2017) study also claimed that the research in this domain is very rare and there is a

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gap in the HR analytics in the gulf region in general [8]. Also the recent work of Alsuliman and Elrayah (2021) has highlighted the gap in this domain and has claimed that the HR analytics projects are currently adopted by individuals or HR professionals, but not yet by organizations. A descriptive survey research design with 168 HR professionals in Manufacturing Companies in the Saudi Arabia was conducted. The study has provided number of recommendations to improve the level of HR analytics adoption and implementation in the Gulf Region [9].

In our study, we are addressing the absence of HR analytics implementation in the governments of the gulf region, specifically the UAE. This study is different than other studies in more than one dimension. The first dimension is that we are conducting an empirical study using advanced statistical techniques. We also use a novel HR data set that has never been investigated or researched upon yet. We use dataset from the UAE Federal Government HRMS system and not from a survey.

Which makes our data high quality, less biased, and with no intuition [27]. Our data set is also different from others, since it includes a diverse 64 different nationalities. The dataset is also covers 20 of different job domains, includes different business functions (core and support) in 42 organizations. The data set includes employees with ranging ages from 20 to 70 years, 6 different education levels, and covers 7 different locations.

In addition, this is the first research that address the HR data analytics in the UAE and its utilizations. This is the first study to explore the UAE employees' behavior against HR policies changes.

1.1 Research Problem, objectives and Questions

In this research, we address the problem of the absence of HR analytics implementation in the government of the UAE. Our main goal is to understand the effect of HR policies changes on UAE employees' behavior utilizing HR data analytics. Hence, we aim at exploring:

- How HR analytics could help HR policies maker to investigate the effect of policies changes on employees' behavior?
- How data analytics could aid the HR policy makers to take data driven decisions?

1.2 Contribution

This paper proposes two contributions:

- This is the first published study using the UAE Federal Government HR data.
- This is the first study to investigate the effect of HR policy changes on Employees in the UAE federal government using HRMS data.

We examined the effect of the HR policies changes empirically through statistical analysis approach. Our empirical investigation led us to formulate our hypothesis as below:

Null Hypothesis: H0: "There is no change in the distribution of leaves taken by the employees before the policy change and after the policy change"

Alternate Hypothesis: Ha: "There is a significant change in the distribution of leaves taken by the employees before the policy change and after the policy change"

The rest of this paper is organized as follows: In the next section, we will cover a great amount of the literature and related work. Then we will explain the procedure we followed in our study (Methodology). Then we will summarize this research results, and at the end we will conclude this paper with the conclusion and discussion section.

II. LITERATURE REVIEW

Data analytics is the exploration and discovery of important and motivating patterns within large volumes of data [3]. When this data is the employees' personnel data such as demographics, education, job details, compensations, it can be a source of HR analytics for knowledge discovery and decision-making. HR data analytics includes many data analytics techniques such as statistics, visualization, and advanced analytics techniques [3].

In Stephens et al. (2020) paper, the author defined the change in organization as "modifications such as stopping over something, continuing it, or taking an initiative for some possible amendments etc" [26]. While Bambale et al. (2021) defined the change as changing the current organization procedures, activities, strategies, systems, policies, management and principles. Most changes in Bambale et al. (2021) point of view would affect stability, employee satisfaction, and trust within organizations [25].

The Human Resources Management Systems (HRMS) showed an important impact in organizations development. HRMS provides the management with the required data to be able to evaluate their employees' performance and improve it in order to improve the organization. HRMS is the source of information where employees can find their data, objective, and tasks. These tasks and objectives are inherited from the organization or business strategy and operational objectives, so it connected the employee with his organization objectives. HRMS enables workforce sustainability, save budgets and increase profits [13].

While Marler and Boudreau (2017) reviewed the literature of HR analytics using 60 articles from different publications. Marler and Boudreau (2017) defined the HR analytics as:" an evidence-based approach for making better decisions on the people side of the business; it consists of an array of tools and technologies, ranging from simple reporting of HR metrics all the way up to predictive modeling". Also Marler and Boudreau (2017) argued that the main four components for HR analytics are logic, analytics, measures, and processes. In addition, Marler and Boudreau (2017) claimed that using explicit theoretical framework is very rare in the reviewed part of the literature. Only 4 papers of the 60 reviewed by the authors are empirical analysis, one of them only linked the HR analytics with organization performance. The results of these empirical researches have shown that there is a strong cause-effect relationship between HR Analytics and financial performance of an organization. The paper summaries the requirements of implanting a successful HR analytics in 3 requirements: having professional and analytical competencies, and a managerial ability to adopt the concept and HR management system. As a conclusion, the good quality evidence-based research is very rare in the topic of HR Analytics [4].

According to Harvard Business 2018 Review [27], Google people analytics department was actively hiring employees, at the same time companies were still struggling in HR analytics investment.

As per Leonardi and Contractor (2018), HR analytics using statistics from employee's data to make decisions are provocative, suspect, and novel. HR collect employee's data but they are not using it in advanced analytics to understand and manage their organizations. HR analytics progress in the past decade was modest compared with the volume and speed of data organizations are collecting. Tata Consultancy Services survey showed that only 5% of the big data investments go to HR analytics. In addition, Deloitte said only 9% of HR professionals understand which Human Capital factor drive performance in their organizations. The authors also claimed that most of the HR analytics depend on individual data more than relational data. Relational data as defined by Leonardi and Contractor (2018): is the data created from files sharing, emails, and chats.

Leonardi and Contractor (2018) also claimed that using Surveys will not generate accurate data and it will get biased results too. They also argue that Companies need to issue HR policies for digital exhaust data gathering and analysis that would be comfortable for employees to understand [27].

In the work of Simón and Ferreiro (2018), the authors conducted a case study using data from multinational fashion company to illustrate the process of HR analytics. Simón and Ferreiro (2018), proposed process is different from other implementations in the sense of developing HR analytics with collaboration of practitioner and scientists. The authors claimed that the gap between researchers and practitioners in the HR Analytics has been consuming a grate part of the literature. The authors argued that the gap is to the level of approaches, language used, and interpretation of the results. In addition to that,

researcher prefers to produce knowledge rather than collaborate with practitioner. The study explains: how research methods and the researcher's management skills can build the basics of HR analytics infrastructure and future practices. The authors also claimed that there are no enough evidences about the strategic usage of HR analytics. Simón and Ferreiro (2018) also addressed number of the challenges and limitations of HR analytics. It also, illustrated the efforts to build a successful HR Analytics infrastructure through collaboration between the researchers and the practitioner. The study determines specific number of skills such as business research methods, analytical skills, question mind-set that derives the objectives, analysis, and interpretation [29].

Minbaeva (2018) argued that HR analytics played an important role in addition to storing huge volume of data and building complicated dashboards. The author claimed that the value of HR analytics constructed of three components. First, HR analytics is the data driven decision tool that changes the decision makers' attitudes to prove their decisions by evidences. Second, it helps the organization to ask the right questions about its employees, performance and plans.

Third, helps the governments to manage changes in behaviors, competences, culture, and processes and being responsible about the change [14].

Alamsyah and Salma (2018) emphasized one of the most important problems in HR analytics. Alamsyah and Salma (2018) argued that, employees' attrition has a massive effect on organizations. There are three different dimensions for the effect of attrition on organizations from Alamsyah and Salma (2018) point of view. First, the cost, effort and time needed to find a replacement. Second the workload if that replacement is not available. Third, the effect of employee absence on client's satisfaction. The analysis done using HRMS data for a telecommunication Indonesian company. The author conducted a forecasting model to predict the employee attrition rate. Advanced data science techniques such as decision tree, and the naive bayes used [15].

Khera and Divya (2018) paper, also used HR analytics to solve the same challenge as [15]. The authors conducted a forecasting model to predict the attrition in IT companies in India. The study shown that SVM technique outperformed other techniques with accuracy of 85%. The study resulted with that: the age, marital status, job level, job profile, and job role strongly affected the turnover in the information technology organizations in India. At the same time, it showed that there is no importance for gender, person previous experiences, and employee's business travels [16].

In the study of Zhang et al. (2019), the author argued that training as HR practice, is not only important for the employees' competencies, but also a guarantee of HR sustainability. The paper studied the employees' training behavior using its social network. The paper explored the employee training behavior and recommended number of actions. The results showed that there is an effect of the society on the corporate training [17].

In the study of Nengsih and Zain (2020), the author used employee time attendance data for clustering analysis. K-means algorithm used to find 3 employees' clusters. Finding different cluster helped the organization to derive decision based on data and to evaluate its employees' performance [18].

The earlier work of Delmas and Pekovic (2018), conducted a clustering analysis too. The dataset consists of 4,640 employees from 1,764 different domains. Also, K-means algorithm has used to find the clusters of employees. The study has found that there is a correlation between the social media behavior of a member and the group innovation in the organization. The study also has found that there is a positive relation between innovation and employee's reward. There is a negative correlation between assignments load and innovation using regression analysis [19].

The goal of Yong et al. (2020) study is to examine the effect of HR environment friendly practices on the organization sustainability. The study tried to align the organization strategies with the environment. The study has focused on six HR

functions. Job Description, recruitment, selection, training, evaluation, and rewards. They conducted a survey to collect the data from a manufacturing domain with more than 200 employees in Malaysia. The empirical study statistical analysis had shown that only two of the six green practices or functions positively influenced the relationship with sustainability. Only green recruitment and green training practices recorded a statistically significant acceptance of the hypothesis. The study has statistically proved that the changes in HR policies toward green HR has affected the employees' behavior. The effect reflected as environmentally commitment and culture throughout the domain of manufacturing. This kind of commitment and culture would maintain the business sustainability [10]. The work of Yong et al. (2020) is relate to ours in the sense of its goal to understand the effect of HR policies changes on the employees. The study also followed an empirical approach, but the study is different in using a survey instead of using the real data it has in the HR systems.

The study of Malik and Garg (2017) is aiming to understand the relationship between HR practices and the employees' flexibility to changes. The HR practices in Malik and Garg (2017) covered are the learning culture, the reviews and discussions, the structure of sharing knowledge. The authors conducted the empirical study was using a questioner that has been answered by 510 employees. The employees are working in 14 different IT companies in India. The research recorded a significant relationship between the studied variables and the ability of employees to adapt with the changes in the HR practices and the organization changes in general. IT also proposed a framework to be utilized in the future by HR professionals and researchers to investigate the effect of policies changes on the workforce. The study claimed that change and innovation are significant sources for competitiveness and commitment to change is a requisite for sustainability, especially in a dynamic domain such as IT. The study argued the aggressive nature of the IT domain in the sense of working in extensive projects, deadlines, dynamic skills, that make this research important. While we believe that this would be one of the weakness points of the study, where it should cover different domains not only IT. The study is also different in using a questionnaire instead of using the real dataset from its ERPs or HRMS. The study is relate to ours in the sense of its target to investigate the effect of HR changes on the employees. The study also followed an empirical approach.

The work of Bodla and Ningyu (2017) had the aim of investigate the effect of HR changes on employee performance and behavior. The data collected from a large multinational technology company in China. The study has used a survey to collect the data from 250 participants. The authors conducted a linear regression analysis to examine the hypothesis. The results have shown that the changes in HR practices positively affecting the behavior of the employee [12]. Bodla and Ningyu (2017) study is different from our study in using a survey not data from the organization HRMS. In addition, they cover only employees in the technology domain while our study includes employees from different domains. The paper of Bodla and Ningyu (2017) is related to our study in investigating the effect of HR practices changes on employee behavior. It is also related to ours in empirically validate its argument that changes in HR practices positively influence employee and organizations performance.

The data were used in Simón and Ferreiro (2018) study collected from 244 Zara stores in Spain with 9112 employee using HRMS. The authors conducted a clustering analysis to understand the different groups of stores. One of the groups were tagged as a very successful in productivity and efficiency. Simón and Ferreiro (2018) concluded with list of recommendations such as the HR departments should start to understand what make these stores successful and share the factors with other stores. At the same time, the turnover rate of the successful stores was very high. The second group was the average group in performance but with the lowest workday hours. The third group is the lowest in productivity and efficiency and the highest rate of absence. The authors also adopted the argument saying that

applications and platforms are capable for data reporting, but not for developing insights about employees and their contribution to the business. Studies have shown that implementing HR analytics is an innovative initiative for HR department. This interest and innovation effort would improve the HR toward resolving the business problems and HR strategic. Although studies have shown that, the distance is still long for HR managers to prove a real adoption of HR analytics [29].

The work of Dalvi (2019) has shown that there is an effect of HR practices changes such as competency enhancement initiatives and the employee performance. The data used in this study were collected from 109 employees in the manufacturing sector using a questionnaire. The analysis has shown that implementing new initiatives in competency enhancement improved the employee knowledge, self-confidence, and job performance significantly [24]. The study is similar to our work in the sense of its objectives and aims, but the data used is collected from questionnaires in a specific domain.

In the study of Iqbal et al. (2020), the authors claimed that the utilizing sustainable leadership in organizations influences the learning and development of employees, authorization, and performance. The study also has proved that higher level of authorizations would lead to sustainable performance. The study collected data form a survey on 369 small medium businesses in Malaysia, Indonesia, and Brunei Darussalam. An empirical analysis was conducted to confirm the hypothesis. The study has reported five different contributions as an empirical proof of the effect of sustainable development implication on organizations. First, it encourages recruitment of sustainable leaders in the organization or training the current manager to sustainable practices. Second, it highlighted the importance of modifying the evaluation systems of top management with respect to the sustainable development goals. Third the need to improve the employees training activities to enhance the organizational development to adapt with future initiatives and projects. Fourth, optimize the learning climate by perceiving the psychology of authorization. Fifth, control the low rate of authorization of stakeholders to maintain the relationship between development and sustainable performance [20]. Iqbal et al. (2020) study related to our study in studying the effect of HR practices on employee behavior such as leadership and training. The authors are also using empirical analysis to validate the proposed hypothesis. The point of weakness of this study are first: using a survey data not data from HRMS. The second weakness is that the author is using data from 3 countries while in our study the data includes 64 different nationalities.

Antcliff et al. (2020) in their paper aimed to explore the characteristics of the organization that outsource HR support and the reasons of such behavior in small and medium-sized businesses.

The authors studied the behavior of employees in organizations that seek such HR practice from different dimensions. The main objective is to explore whether these organizations use outsource employees pursuing HRM information or strategic HRM. The data used for this study is the UK Longitudinal Small Business Survey or LSBS collected from 15,500 respondents in the year of 2015. In addition to the survey, the authors interviewed 9,123 employers with at least one employee plus the business owner or partners. The survey analysis has shown that few small to medium business outsource HR support for the purpose of HR information than strategic HR. The analysis also has shown that the reason of this practice is employee shortage during organization changes and challenges. The authors conducted a hierarchical binary logistic regression to study the effect of attributes such as demographics, problems with HRM on strategic HR. The research also studied the likelihood of an organization to seek HRM information or strategic consultancy [30].

The paper of Ahmad et al. (2020) aimed to explore the effect of knowledge based HR practices on innovation. The authors argued that transforming from classical HR to Knowledge base HR would improve the HR services. The study has covered 278 sample from small and medium size business using a survey from Malaysia. The study results shown that

knowledge-based HR practices positively affect the innovation in the targeted organizations. The study has also proved that using knowledge-based HR practices provides dynamic capability to business dimensions such as projects management, marketing skills, and technology [21]. The study is related to ours in the objectives but not in the implementation. It covers small and medium size private business not governmental organizations. It also used data from a survey not from the HRMS.

The work of Mattar (2021) studied the employees' acknowledgments of the organization innovation role in their acceptance and readiness behavior during emergency. It also addresses the importance of using social media during the crisis for knowledge sharing and support from the organization policies maker. These two HR practices have their effect on the employees' behavior and reactions. The data used in the study was collected through a semi-structured interview with 10 faculty members in a Lebanese university. The results has shown that during crisis the organization innovation had been activating the adaptation of change within its employees. The urgency enhanced the commitment of change adoption and implementation within organization employees. One of the important result of this study is that it shows that innovation implementation requires a cooperative approach. It also shows that knowledge sharing using informal mechanism and person-focused development is a mean of adaptation with crisis. The study has found that the proactive supporting nature or behavior of employee is a culture related phenomena especially in assembled cultured environment. In addition, it encourages the managers to introduce new conditions that would change the environment frequently to keep their employees practicing the dynamic mode of changes and minimize the stress and anxiety [22]. The study is related to ours in the objective of studying the employees' behavior against changes, but it is different in the data used to investigate this.

While in the work of Ali et al. (2021), the authors conducted statistical analysis to explore the relationship between employee satisfaction and motivation at work. The study also investigated other factors such as culture, rewards, relationship between the employee and the manager. The data collected from 128 questionnaires with banking employees. The result has shown that compensations have strong correlation with job satisfaction. It also shown that motivation and recognitions of motivation has significant positive relationship with job satisfaction. The study also highlighted the effect of frequently training and development on employee satisfaction compared with seasonal training [23]. The research is similar to ours in the sense of the objectives and aims and the methodology, but it is different in the type of dataset used.

In the work of Bambale (2021), the authors claimed that HR practices such as employee motivation, employee commitment, and trust building have significant effect on organization changes. It also highlighted the importance of collaboration between employees to achieve a successful change. The paper addressed the importance of organizational practices changes, especially with dynamic and competitive business world. It also has explored the change culture and communication effect on the organizational change process. The authors have conducted 292 questionnaires with employees and managers in the medium and large manufacturing enterprises in Kuala Lumpur, alaysia [25]. The objective of the study is opposite to our goal. The study studied the effect of employees' behavior on the change process. The study used a questionnaire not HRMS dataset.

In Jaakko Airaksinen study, the author built a prediction model to predict the risk for long-term sick leave. The author argued that sick leaves considered as a major challenge for organizations and companies. It would also be a sign for early death or disability. Forecasting that an employee is in a risk of long-term sick leave will prepare the organization to avoid this risk. It would also alert the employee to change his life style and the organization to improve the wellbeing of its employees. The data collected from the Finnish Public Sector (FPS) study and the Health and Social Support (HeSSup) study for Finland from

65,775. The author validated the prediction model using 13,527 public-sector employees. The author combined the data with Survey responses on work and lifestyle questions for the same employees.

The surveyed employee are from different age groups starting from 20 to 54. The employees are from municipal domain of 10 Finnish towns during 2000- 2004. The author focused on sick leave more than 9 days. The author was able to use the model to explain the risk of long-term sick leave >=90 days. The model uses 46 predictors but it was reduced to 17 using LASSO regression. These predictors include depression, obesity, age, gender, socioeconomic position, shift work, working at night, health issues history, smoking.

The study used Cox proportional hazard regression models to build multifactorial predictive algorithm to predict the long-term sick leave >=90 days with (C-statistic 0.73) discriminative ability [31].

While in the research of A. van Drongelen, the author built a predictive model to forecast the long-term sick leave for the employees in Netherlands Airline Company. Demographic and job related data collected between the years 2005 to 2008 for 7,652 employees using human resourced data. The long-term sick leave considered in this study is >42 consecutive days.

The author used logistic regression technique to build the prediction model and it was validated internally for the year of 2009 data. The two-step prediction technique started by a preselection of the predictors using univariate logistic regression.

The predictors with the lowest P value are chosen. Then all the important predictors were used in a multivariate logistic regression using automatic backward selection procedure. The author used Hosmer–Lemeshow test to evaluate the goodness of the models to fit. In addition, the author used the Bootstrapping techniques to validate both models internally by simulating their ability to explain the variance and the discriminant analysis. The best predictors found for this study is a combination of high age, pregnancy, having parking permission, high job risks, previous sick leaves, and marriage in the same period (2005-2008). The data includes other variables such as gender, nationality, skills, job titles, service period, etc. The explained variance by the regression model was low (<15%), so the author recommended that extra attributes should be included in the future to predict the sick leave with higher accuracy [32].

The work of Lauren A., 2019 aimed to explore the association between shift work disorder and emotional health for nurses in a hospital. The data includes 200 nurses in the age between 21 and 65 years and from 0 to 45 years of working in shifts, and 95% are females. The data collected from survey for demographic attributes and Shift Work Disorder Questionnaire, while the sick leave details collected from HR system. The author used the backward linear regression analysis using statistically significant variables. The model succeeded to predict that 59 nursed are in high risk of mental health problems and increase in sick leaves because of work shifts disorder. Shift work disorder played an important role in determining the nurses at high risk of High depression and anxiety. The model has explained the High depression by 18.8 %. While combining Shift work disorder with night shifts and alcoholic drinks explained 49.7% of the anxiety. Depression and working in shifts for years are accountable about 18.9% of the increase in sick leaves [33].

III. RESEARCH HYPOTHESIS

In our study we are aiming to explore, How HR analytics could help HR policies maker to investigate the effect of policies changes on employees' behavior? And How data analytics could aid the HR policy makers to take data driven decisions?.

The HR policy changes we are investigating is the changes in annual leave from 30 working days into 22 working days that happened in UAE federal government the year 2017.

We are trying to find out if there was any statistically significant change in the Alternate leaves taken by the employees after reducing their annual leaves from 30 days per year to 22 days per year. The study intends to see how the

behavior of the targeted employees changed towards utilizing the other types of leaves or Alternate leaves that they are allowed to avail. We are defining our Null (H0) and Alternate hypothesis (H1) as below:

Null Hypothesis (H0): "There is no change in the mean distribution of the alternate leaves taken by the employees before the policy change and after the policy change"

Alternate Hypothesis (H1): "There is a statistically significant change in the mean distribution of the alternate leaves taken by the employees before the policy change and after the policy change".

We set a Confidence interval of 95% for this study. Therefore, we will conduct an experiment to measure the relationship between two variables (dependent and independent variables). The dependent variable is the mean of the alternative leave after the policy change. The independent variable is the mean of the alternative leave before the policy change.

IV. DATA COLLECTION

In this study, we use the experimental research method to test our hypothesis. We design this experiment based on real-world use case using real data from live HRMS.

The HRMIS System of UAE Federal Government maintains the data of 100,000+ employees spread over a grade structure of 1 to 14 and some special grades. Out target population is a pool of 6,997 employees from grade 1 and grade 2 who had 30 annual leaves per year. These 30 days was changed and reduced to 22 annual leaves per year based on a Decree issued by the Cabinet in the year 2017. We have collected the federal government employees' leave data for the years 2015,2016,2017,2018 and 2019. As, the law change was done in the year 2017, we consider this as the base year and treat the 2015 and 2016 as source of data of leave patterns of employees before law change years. Similarly, data of leave patterns of employees in the years 2018 and 2019 are considered as after law change years. We are not considering the employee leaves in the year 2017 as there accruals were rebalanced in this year, which would add bias in our research study. In addition, we did not consider the year 2020 due to the covid-19 pandemic and the work from home special case. Figure 1 is showing the sample dataset partition.

In the UAE federal government HRMS, the grade structure has 14 grades. The Law changes regarding the annual leaves reduction was applied on the employees falling in the first and second Grade. The total employees in these grades (1st & 2nd) were 7,900.

Primary Dataset Attributes	Description
Leave Type	Types of leaves – Annual , Sick, Absence, Permits, Unpaid Leaves, Chronical Leaves Categorical Values
Number_Of_Leaves	Numeric Value
Leave Duration Type	Hours, Days, minutes Numeric Values
Leave Date	DateTime Value
Employee Name	Varchar
Secondary Dataset Attributes – Employee Basic Information	
Age	Numeric Value
Gender	Categorical Value
Location	Categorical Value
Marital Status	Categorical Value
Nationality	Categorical Value
Salary	Numeric Value
Job	Categorical Value
Grade	Categorical Value
Contract Type	Categorical Value
Job classification	Categorical Value
Job Family	Categorical Value
Hiring date	DateTime Value
End of service Date	DateTime Value
Location	Categorical Value

Below are number of considerations and inclusion/exclusion criteria that were put in place to have the best possible data set for our research and study:

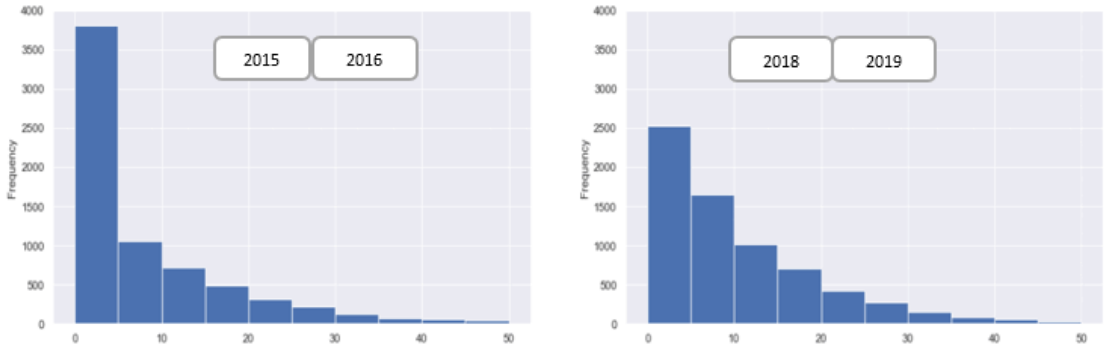
1. We considered the employees who were employed and active in the government throughout this period of study (2015 to 2019).
2. The employees who had exemptions based on their health factors, approved long leave cases, Diplomats who were on missions in different countries were excluded from this study to avoid bias as they were exempted from this decree.
3. We are not considering the employee leaves in the year 2017 as there accruals were rebalanced in this year, which would add bias in our research study.
4. We did not consider the year 2020 due to the covid-19 pandemic and the work from home special case.

The following list of leaves are named as a logical "Alternative Leave" that an employee can avail along with the primary Annual Leave:

1. Absences: When an employee is absent from work and has not applied for any of the other leaves.
2. Sick Leaves: When an employee avails leave up to 5 continuous days due to health reasons and provides a valid medical certificate.
3. Unpaid Leaves: When an employee avails a loss of pay leave.
4. Permits: An employee avails exit permit leaves from office (Maximum of 2 hours in a working day due to personal or medical reasons)

V. DESCRIPTIVE ANALYSIS

Below is a graph which shows the distribution of the employees who availed the leaves in the brackets of 0-5,5-10,10,15,15-20,20-25 and so on (in bins of 5 leaves). The left hand side graph is showing the distribution of the before law change years. Similarly, the right hand side graph shows the distribution of employees in the leaves buckets after the law change.



We can clearly see that the number of employees taking more number of alternate leaves have increased after the annual leaves were reduced from 30 days to 22.

Further visualization in figure 4, 5 and 6, showed us that, the before law change mean of 8.20 alternative leaves has shifted and increased to 10.68 alternative leaves. Therefore, the mean distribution difference has shifted to the right for the leaves taken after the law change.

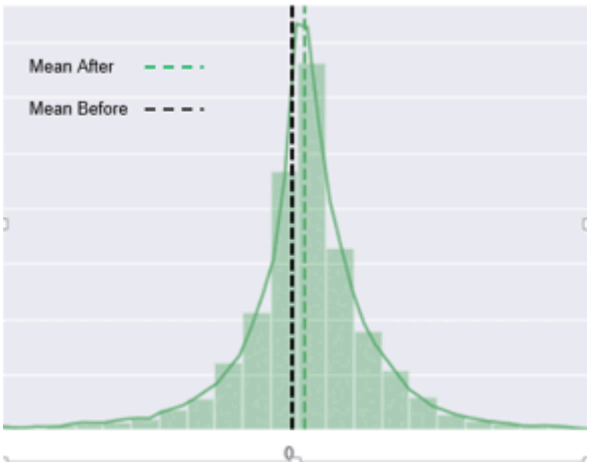


Figure 5: Difference in Means of Alternative Leaves before and after

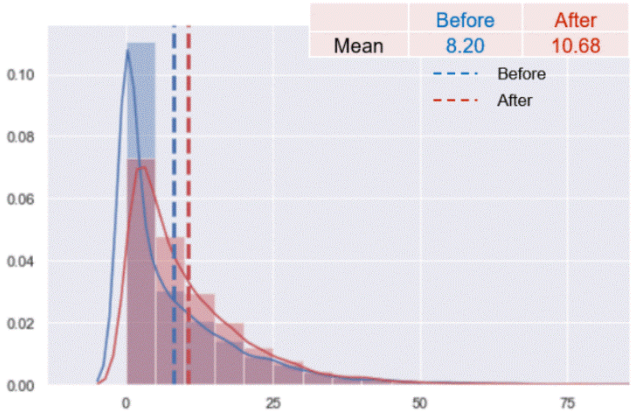


Figure 6: Alternative Leaves Means Distribution before and after

VI. STATISTICAL ANALYSIS RESULTS

In the previous section, we have visually established that there is an increase in the mean or average number of leaves. In this section, we used statistical Z-test to validate our hypothesis. The P-Value for the Z test were as below:

	Before Law Change	After Law Change
Mean	8.204422936	10.68238994
Known Variance	139.73	127.3
Observations	6996	6996
Hypothesized Mean Difference	0	
	-	
z	12.68353732	
P(Z<=z) one-tail	0	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0	
z Critical two-tail	1.959963985	

Figure 7: Z test to test the hypothesis

Since, the p-value is less than 0.05, we reject the null hypothesis H0 "There is no change in the mean distribution of leaves taken by the employees before the law change and after the law change".

As shown in the z-test leaves results in Figure 7 (controlled change vs effect of change), the alternative leaves impact changed from 8.2 (before the change from 30 annual leave days) to 10.68 (after the change to 22 leave days).

The percentage of change increased from the expected of -26.70% to + 30.20%. Therefore, instead of decreasing the days of leaves by 26.70% as expected by the policy makers, it increased by 30.20%. From the above z-test, we argue that:

1. There is a statistically very high significant change in the number of 'Alternative Leaves' availed by the employees as a result of the reduction in their annual leaves.
2. The number of leaves for the same population set increased from 57,399 before (2015,2016) to 74,734 for the years (2018,2019)
3. The 26.7% change in the 'Annual leaves' (controlled change from 30 to 22 working days) resulted in an increase in the 'Alternate leaves'(uncontrolled change) by 30.2%
4. Our conclusion was that the average or mean alternate leaves taken by the employees increased by 30.20% after their annual leaves were reduced by 26.7%.

Further to our analysis to find out which of the Alternative leaves increased, we performed the same test for all the 4 alternate leaves individually. Below are the results.

Absences	Before	After
Mean	2.26	2.17
Known Variance	14.20	11.76
Observations	1605	1605
Hypothesized Mean Difference	0.00	
z	0.69	
P(Z<=z) one-tail	0.25	
z Critical one-tail	1.64	
P(Z<=z) two-tail	0.49	
z Critical two-tail	1.96	

	before	after	% Change
Controlled Change	30	22	-26.7%
Effect of Change	2.25	2.17	-3.9%

No Significant Changes in Absences as the p-value is .25 which is < 0.05 (confidence interval) and we fail to reject the null Hypothesis H0.

Sick Leaves	Before	After
Mean	6.47	8.68
Known Variance	91.56	61.30
Observations	6372	5869
Hypothesized Mean Difference	0.00	
z	-14.02	
P(Z<=z) one-tail	0.00	
z Critical one-tail	1.64	
P(Z<=z) two-tail	0.00	
z Critical two-tail	1.96	

	before	after	% Change
Controlled Change	30	22	-26.7%
Effect of Change	6.47	8.68	34.2%

Very Significant Changes in Sick Leaves as the p-value is 0 which is < 0.05 (confidence interval) and we reject the null Hypothesis H0.

Figure 8: Z-test for different alternative leaves –part 1

Unpaid Leaves	before	after
Mean	5.48	5.91
Known Variance	88.73	61.28
Observations	946.00	590.00
Hypothesized Mean Difference	0.00	
z	-0.97	
P(Z<=z) one-tail	0.16	
z Critical one-tail	1.64	
P(Z<=z) two-tail	0.33	
z Critical two-tail	1.96	

	before	after	% Change
Controlled Change	30	22	-26.7%
Effect of Change	5.47	5.91	7.9%

No Significant Changes in Unpaid leaves as the p-value is .16 which is < 0.05 (confidence interval) and we fail to reject the null Hypothesis H0.

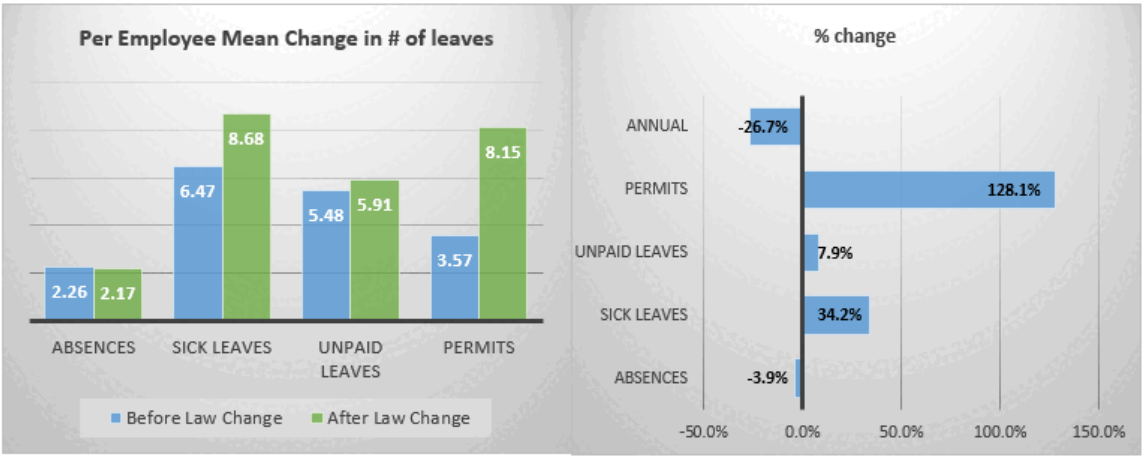
Permits(Medical/Personal)	before	after
Mean	3.57	8.15
Known Variance	27.44	73.98
Observations	2067.00	2067.00
Hypothesized Mean Difference	0.00	
z	-20.66	
P(Z<=z) one-tail	0.00	
z Critical one-tail	1.64	
P(Z<=z) two-tail	0.00	
z Critical two-tail	1.96	

	before	after	% Change
Controlled Change	30	22	-26.7%
Effect of Change	3.57	8.14	128.1%

Very Significant Changes in Permits as the p-value is 0 which is < 0.05 (confidence interval) and we reject the null Hypothesis H0.

Figure 9: Z-test for different alternative leaves –part 2

As in the below figure the Annual Leave reduction caused a very significant increase in the Sick Leaves by 34.2%, and the Exit Permits by 128.1%.



VII. DISCUSSION AND FUTURE PLAN

Employee data dimensions from relational data, social media details, etc. have been automated and stored in HRMS databases. New positions, qualifications, functions, roles and organizations will be created and feed HRMS systems. On the other hand, investigating the hidden knowledge within this huge volume of data is still emerging.

The research that we have reported in this paper had one main objective which is: to understand the effect of HR policies changes on UAE employees' behavior utilizing HR data analytics. While we were in the way of achieving the above goal, we have recorded two contributions:

- This is the first published study using the UAE Federal Government HR data.

The reviewed literature has been showing that there is a gap in this topic [4,5,6,7, ...]. The gap is significant when we surveyed the region researches such as in [9].

- This is the first study to investigate the effect of HR policy changes on Employees in the UAE federal government using HRMS data.

The related work, about the effect of HR practices on employee behavior, has also shown that the researchers and practitioners rarely use HRMS data. Most of the published work use data collected through surveys or interviews.

In our study we have shown how the policy change causes an unaccounted negative change in the other areas of interest. When the annual leaves were reduced, the Sick Leaves and Exit Permits increased by 34.2% and 128% respectively for the targeted employees. Based on this study, we concluded that any future change in Annual Leave policy has to account for this aforementioned unaccounted factor before the implementation of the law. The study helps the organization to be aware of a future risk, which is the absence of employees or talents because of HR low changes. If the employees are handling critical and leadership positions, this risk will be serious business challenge.

Detailed studies are further to be conducted on the effect of this policy on the employee attrition, employee satisfaction vs the organizational goals and effect of this policy change on productivity of the employee. Also, it would be interesting to see the demographics around the increase in the sick leaves and exit permits. For example, on which age group/gender/nationality the impact of this policy change was the most.

One of the important knowledge that organizations would give attention to is to understand their employees' reactions toward policies changes using data form HRMS not through surveys. The usage of HRMS data has led to interesting knowledge and insights that has statistically proved with no intuition as per the results of our study and literature [27] as well.

The domain of HR Analytics is holding important promises not only for researchers but also for stakeholders. HR analytics would be a mean of improving classical decision-making approaches in organizations. It would also help the organization to resolve strategical challenges and improve workforce and services.

As a future plan, decision makers in the government should use HR data analytics as a prerequisite for any future change or decision to be taken. Trying to find core business problems or challenges that would be resolved by HR Data Analytics is inspiring. Also using different HR datasets in conducting other data analytics studies is important. Extra efforts to integrate different datasets such as emails, or Customer Relation Management, social media, or other data that would add different dimensions to the analysis.

Studying other dimensions of employees' reactions such as turnover rate against changes in an organization is required. Trying to apply different data analytics tasks such as clustering or association rules in government HR data deserves pursuing.

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The Impact of Technology on Knowledge Retention: A Systematic Review

Dr. Sallam Alsarayreh

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ABSTRACT

Innovative Technologies of the 21st century, such as Haptic technologies, 3D printing, Chatbot, data mining, and brain-based learning played an essential role in E-learning, and interactive teaching techniques to support student knowledge management and knowledge retention. This study aims to provide a comprehensive analysis of five research articles published in the conference proceedings and journals. The main findings of this study indicate that among the technologies mentioned earlier, E-learning and virtual environments, where the most technologies studied in the field, have a significant impact on knowledge retention. Furthermore, questionnaires and actual tests for some technologies were the mainly used research method in data collection in the context of the effect of technology on knowledge retention. This study attempts to show the recent research progression made in studies considering the impact of technologies on knowledge retention. We used a systematic literature review (also known as a systematic review) to locate, review, and analyze all related studies on a specific research subject, topic field, or phenomenon of interest(Kitchenham et al., 2009).

Keywords: knowledge retention in education. use ai in knowledge retention, data mining techniques, chat-bot in education, haptic technologies in education, three dimensions printing, brain-based learning, the effect of technology on knowledge retention, systematic review.

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I. INTRODUCTION

In an age of digital transformation which transformed the educational possibilities to ensure the knowledge transfer and retention that the technology benefits students by breaking down barriers in education and providing a blissful moment in a variety of settings and subjects (Iyer, 2020). This study's focus is educating people in the field of conceptual learning, with more realistic examples of how to use technology to recreate the nature of practical understanding in the educational world and retain the knowledge of the students.

Knowledge retention is critical in many industries such as government, health, banking, and education. Considering COVID19 (viruses that infect humans) pandemic and transforming the learning method from manual-based to e learning, we observe the importance of developing the education method and saving the knowledge granted. This paper will focus on the impact of the new technologies to assist students in learning their general knowledge subjects and the impact of these technologies on knowledge retention instead of the traditional way. We conducted a systematic literature review for research on knowledge retention and the effects of technology usage in education to provide a thorough overview of the current studies and discuss the implications of the findings.

Teachers want their students to remember details for more than a week rather than memorizing facts for an exam. Teachers are finding it challenging to teach an ever-increasing amount of material. The Effect of Technology on Motivation and Retention for Covering a broad curriculum result in solid memories in students(Granito, Chernobilsky and Granito, 2012). Teachers must find different ways to teach the appropriate material and help students retain the requisite knowledge due to the demands of standardized tests (Granito, Chernobilsky and Granito, 2012).

This paper will survey selected literature regarding the aspects of Haptic Technologies was introduced by L. Liu et al. (Iyer, 2020), which simply means "ability to touch" or "ability to grasp" (Revesz, 1950), is a user interface that allows them to touch virtually, force or control objects formed and/or displayed in a visual context (Hegedus, 2013), besides the use of three-dimensional printing in the classroom to remove obstacles to learning how students think and incorporate knowledge into proper subjects (Iyer, 2020) Including AI technologies such as Chat-bots which have the ability to mimic human conversation and can offer personalized services (Dutta, 2017), along with interactive mining, which enable users to be able to adjust the objective of a search on the fly, refine mining requests based on returned results, and drill, dice, and pivot through the data and information space interactively with interactive mining (Han, Kamber and Pei, 2012), and the philosophy of brain-based or brain-compatible learning theory focuses on concepts that provide an incentive for maximum knowledge acquisition and retention (Furlong, 1982).

The questions that guided this study were

Research Question 1: How can technologies support knowledge retention?

Research Question 2: Are the new technologies require to change the teaching methods and approaches? Discussion: Could we replace the teacher in the future?

II. LITERATURE REVIEW

Knowledge retention for curriculum learned is a challenge that persists in education, even though many methods help students maintain their knowledge. We see several technologies used in education to improve teaching in the twenty-first century, with the digital transformation reconstruction and improving the education system. Our literature review analyzes five related studies on using the new technologies in education and how they affected knowledge retention.

Virtual reality (Haptic System) is the first technology, which imitates sight, i.e. the sense of being present in the real world. Low-cost consumer VR headsets like the Samsung Gear VR, Google Cardboard, and Google Daydream have created a more open digital world than ever before. Individuals who had spent time in a virtual reality environment were polled, and the findings were interpreted using the theories as a guide. Virtual reality (VR) has also altered the educational environment. The main aim was to show that the Virtual Haptic System could be a helpful interaction technology for improving human ability in educational settings.

Accordingly, empirical evidence shows that technology benefits students by breaking down barriers in education and producing pleasurable moments in various contexts and topics, all of which affect their knowledge retention (Huang et al., 2019; Iyer, 2020).

Three-dimensional printing is another technique that is particularly useful for a variety of topics and even subjects at various levels of education. Teachers, for example, will print historical objects such as monuments and coins. Biology students can print organs and cells, and geography teachers can print a mountain range, and so on, paving the way for creativity and innovation in the field of education. The use of 3D automation in the classroom removes obstacles to learning how students think and incorporate knowledge into valuable subjects. (Iyer, 2020).

Chat-bot's can have a hugely positive effect on learning in education (Dutta, 2017). High school students react well to educational technologies such as conversational intelligent tutoring systems (Rus, Niraula and Banjade, 2015).Users go to Google, Yahoo, or other information retrieval systems to get information, but they get documents or links that are not important or useful. As a result of the need to solve such issues, the concept of a natural language dialog system emerges, in which a user asks a question in natural language and the system responds with a succinct and reasonable response (Abu Shawar and Atwell, 2007). The findings on students' learning outcomes and memory retention are contrasted between conventional search engines (Question Answering System) and intelligent

chat-bot systems. The findings show that using intelligent chat-bots to learn affects students' learning outcomes and memory retention.

Dialogflow.com (formerly Api.ai) intelligent chat-bot developed to assist high school students in learning general knowledge or social science subjects for the very important function that seeks to develop sub-intents in the light of a specific purpose(Dutta, 2017).

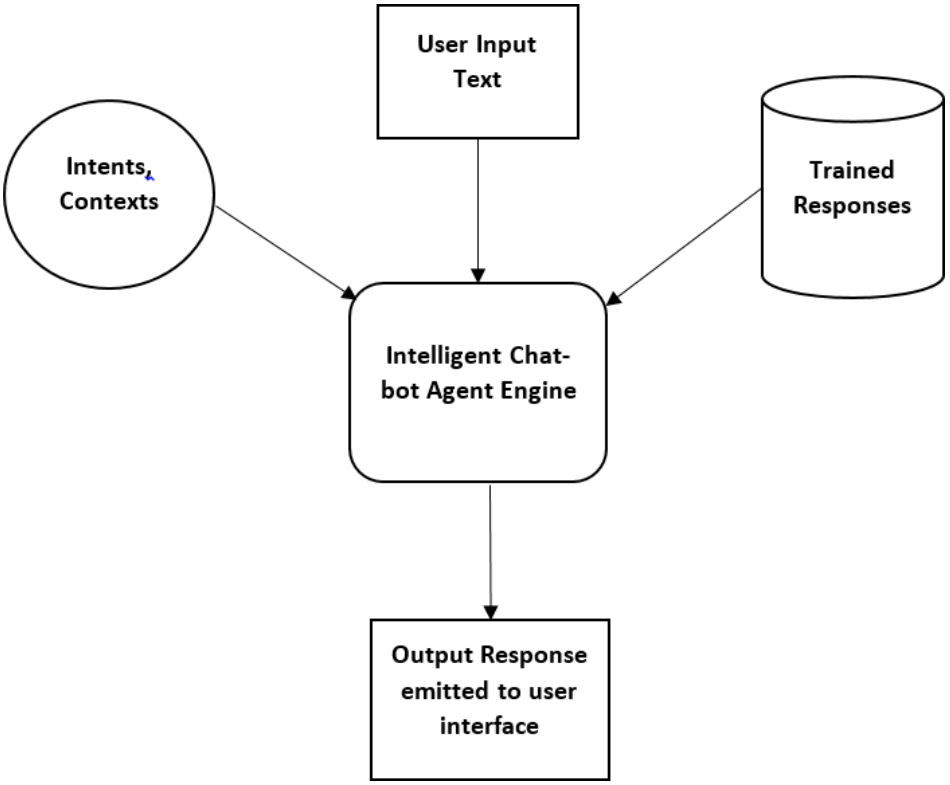

Fig. 1: Architecture of Propose Intelligent Chat-Bot (Dutta, 2017)

The work of (Koşar and Bedir, no date) presents an insight on the impact of brain-based learning on the retention of the English language on young adult trainees. The researchers utilized intervening the brain-based learning principles of the participants for nearly four and a half months.

The consequences of the proficiency tests regulated toward the start of and after the intervention were broken down with an end goal to investigate whether brain-based learning intervention applies influence concerning the improvement of test subjects' proficiency in English. The outcomes of the retention test directed a half year after the post-proficiency test were investigated. An interview was directed both after the post-proficiency and the retention test to acquire knowledge of the test subjects' perspectives on the brain-based learning intervention. The main findings achieved from examining both quantitative and qualitative information suggest that knowledge retention could be enabled by building up a learning climate viable with mind-based learning standards.

The work of (Ji et al., 2018) sheds light on the issue of supplementing insufficient data into the case-based reasoning methodology (CBR) by the duplication of suitable values can diminish the possible negative impacts on the solutions emerging from abrupt alterations. The case-based reasoning approach essentially depends on chronicled cases to take care of new issues. The problem stems from CBR researchers rarely inspecting the issue mentioned above. Moreover, to address the issue, the researchers proposed a knowledge retention based learning method that is based on CBR by utilizing a data mining method to administrate missing values of the

dataset. The learning technique with the CBR model accomplished higher precision of the general expense assessment and higher constancy in contrast to the past model. This exploration shows how cases can be created and considered as learning retention cases to conquer the hurdles of continuous updates in a wide scope of projects of construction in nature, in addition to that, it demonstrates why the case bases should be updated on a frequent basis.

Data mining, on the other hand, should have been renamed "information mining from data."(Han, Kamber and Pei, 2012).

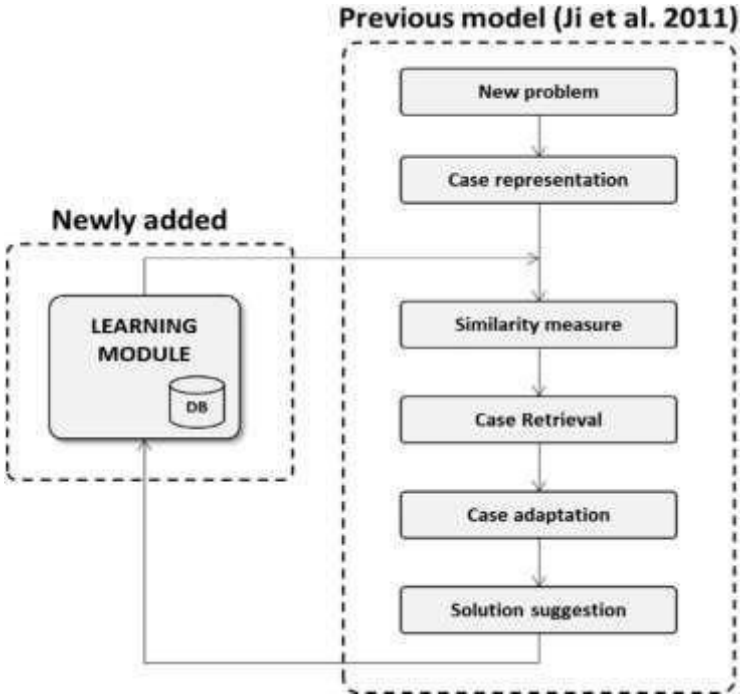

Fig. 2: Comparison of the Case-Based Reasoning (CBR) Model schemes. (Ji Et al., 2018)

Based on the existing literature, the current review research aims to add value to the body of knowledge by focusing on the effect of these innovations on knowledge retention in education and how we can use them.

III. SYSTEMATIC LITERATURE REVIEW METHOD

In this paper, we used a systematic literature review (also known as a systematic review) to locate, review, and analyze all related studies on a specific research subject, topic field, or phenomenon of interest (Kitchenham et al., 2009). A systematic literature review has many benefits by summarizing the current facts about the technology, such as the effect of paper-based manual and stereoscopic-based mobile (Lam, Sadik and Elias, 2021). Moreover, find any gaps in existing research so that areas for further study can be suggested.

Systematic reviews begin with the development of a review protocol that defines the study issue to be answered as well as the methods to be used to conduct the review. Systematic reviews are focused on a pre-determined search method that seeks to find as much relevant information as possible. In order to properly place new research activities, a framework/background must be provided. (Kitchenham et al., 2009).

3.1 Identify the Research Goal and Research Questions

This paper aims to conduct a comprehensive analysis of relevant literature to depict the effects of digital transformation technologies that enable e-learning and virtual worlds and test a new approach for ensuring long-term student knowledge retention. Our research questions were developed using the PICOS model (The PICOS tool focuses on the Population, Intervention,

Comparison, Outcomes, and Analysis of article) (Methley et al., 2014)The following information is given to help us develop our research questions:

Question number one: How can technologies support knowledge retention?

Question number two: Are the new technologies require to change the teaching methods and approaches?

Question number three to be discussed: Could we replace the teacher in the future?

3.2 Identify the Keywords

In the research text, we used the most related keywords to our mentioned question, starting from "knowledge retention" And "knowledge retention technologies."

Then we got interesting articles in practice 21st technologies in teaching, improving the students' knowledge retention in the long term. Accordingly, we expanded the keywords to cover "Data mining techniques" And "AI technologies used in education. Also, a string of "Haptic technologies in education.

3.3 Our inclusion criteria are shown in Table 1. Each study found in the search results must meet these criteria in order to be included in our SLR

Table 1: Identify the Inclusion/ Exclusion Criteria

Standard	Inclusion/ Exclusion
Date	The study has to be published in 21st century and provide accurate and updated information in the revolution age. Outdated information has to be excluded.
Language	The study has to be writing in English or translated to English.
Participants	The article study made on students in education sector.
Keywords	The article has to be related to the search keywords: Knowledge retention. Use AI in Knowledge retention · Data mining techniques Chat-bot in education. Haptic technologies in education. 3D printing. Brain- based learning. The Effect of Technology on knowledge retention. Systematic review
General criteria	Must meet the research keywords conditions and from approved resources.

3.4 Data Source and Search Strategy

For the present Systematic literature review, the following online library databases and search engines were used: Gartner, Google Scholar, Springer, Elsevier and Search gate. According to the study's creators, these databases would be the primary sources for gathering papers relevant to the Impact of Technology on Knowledge Retention.

The keywords mentioned earlier yielded 30 papers in the search results. One paper was found duplicated, and they were removed. As a result, the total number of articles left is now 29. The authors verified each study's inclusion and exclusion criteria. As a result, seven research papers were identified as meeting the inclusion criteria and were included in the study. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) were used to conduct the search and refinement stages of this review shown in Table 1. Identify the Inclusion/Exclusion Criteria. The search and refinement stages in this review study were carried out according to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) (Moher et al., 2009). Fig. 3 shows the PRISMA flowchart.

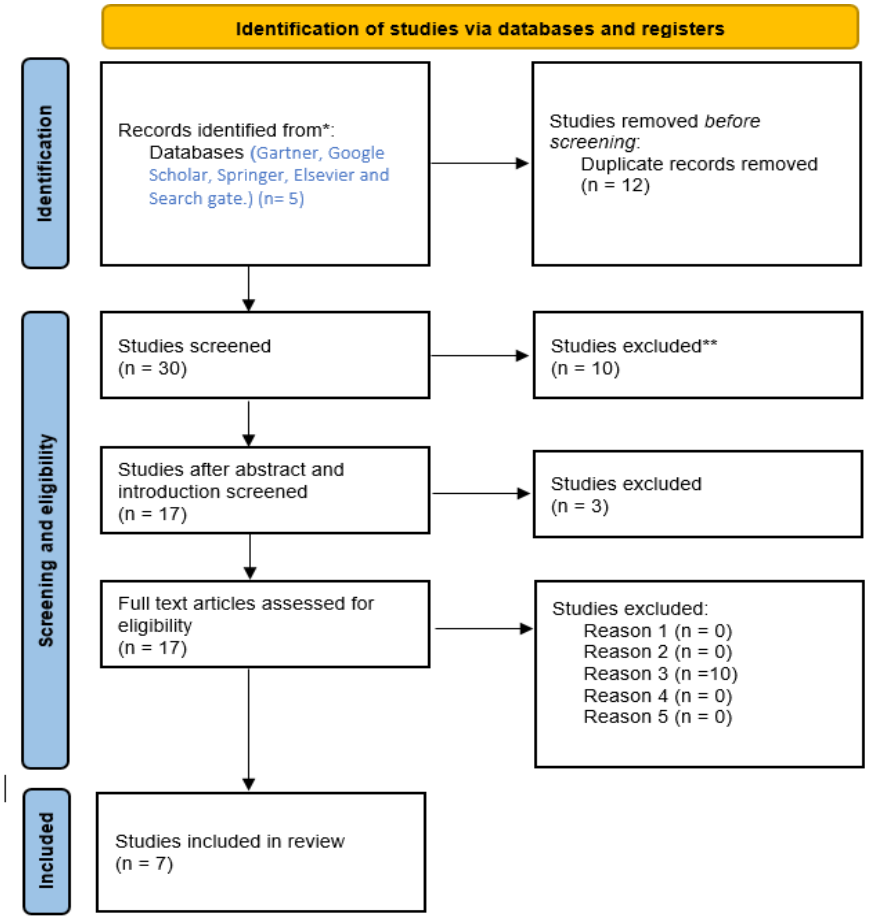

Fig. 3: PRISMA Flowchart for the Selected Studies

3.5 Quality Assessment

Along with the inclusion and exclusion requirements, the quality evaluation is an important consideration to consider (Al-Emran, Mezhuyev and Kamaludin, 2018). To include a way of appraising the content of the research papers that were retained for further review (N=5), a quality evaluation checklist as below:

1. Is there something in the analysis that you did not know or understand before?
2. Is the study's information system/technology clearly defined?
3. Is the research relevant to the field of education?
4. Is the technology mature and widely available?
5. Is the literature search comprehensive enough to include all relevant studies?

The checklist was based on suggestions made by (Kitchenham et al., 2009). Each query was graded on a three-point scale, with a "1" representing "Yes," a "0" represents "No," and a "0.5" representing a partial point.

Table 2: Quality Assessment Results

	Question # 1	Question # 2	Question # 3	Question # 4	Question # 5	Total	Percentage
Study number 1	1	1	1	0.5	0.5	4	80%
Study number 2	1	1	1	0.5	1	4.5	90%
Study number 3	0.5	1	1	1	0.5	4	80%
Study number 4	1	0.5	0	0.5	0.5	2.5	50%
Study number 5	0.5	0.5	0.5	0.5	0.5	2.5	50%

IV. RESULTS AND DISCUSSION

This study reports a "systematic literature review" regarding the impact of technology on knowledge retention education. This study's focus is educating people in conceptual learning, with more realistic examples of how to use technology to recreate the nature of practical understanding in the educational world and retain the students' knowledge. The study reviewed 30 research articles related to open the discussion on our research questions and comment on the exciting results we found from the extracted data in this section:

Research Question 1: How can technologies support knowledge retention?

We believe that the answer to this question lies in three areas of the current education problem, the use of the technology and ability to implement:

The problem is related to retain the knowledge that has been getting and the challenge that persists in education. Even though many methods help students maintain their knowledge, but this problem still exists. The use of technology has created a more open digital world (Iyer, 2020), which has changed educational possibilities and promoting students by overcoming educational barriers and generating blissful moments in various contexts and across various subjects.

We have been representing how the technologies of VR, 3D printing, chat-bot, data-mining and brain-based education have a significant impact on knowledge retention by

- Creating a path for creativity and innovation in the field of education (Huang et al., 2019; Iyer, 2020)
- Using mentioned technologies together would enable professors to immerse students in an intense environment where they can perform several tasks at once, such as visualizing and designing new objects or 3D models, in order to better understand the concept in a fun and imaginative way. (Huang et al., 2019; Iyer, 2020)
- The intelligent chat-bot tool will be trained on a knowledge base of general knowledge questions and answers, and it will be able to engage in small conversations with its users. (Dutta, 2017) (Abu Shawar and Atwell, 2007) (Abbasi and Kazi, 2014)
- Brain based learning more logical and effective learning method (Koşar and Bedir, no date)
- More reliable estimation results were obtained when the number of retained cases was increased using the learning process.(Ji et al., 2018)

Considering COVID19 (viruses that infect humans) pandemic and transforming the learning method from manual-based to use the technologies provide users with the advantage of depth perception, which may aid in memory improvement (Lam, Sadik and Elias, 2021).

Research Question 2: Are the new technologies require to change the teaching methods and approaches?

Traditional teaching methods include rote practice in which students are expected to take copious notes, and vocabulary, in which students are expected to memorize meanings and spellings of key terms. This approach has been shown to be effective in passing exams while still retaining information over time. Instead, students should employ the elaborative meaningful learning technique. When students are taught using 21st-century technologies, they are more likely to maintain the knowledge for a longer time. Students would be able to remember new knowledge more quickly if they collect new information that is foreign to them and compare it to information they already know. (Granito, Chernobilsky and Granito, 2012)

Teachers in traditional classrooms must use innovative resources to encourage students' imagination and devote a significant amount of time to researching the effect of each method on students' actions and outcomes.

Computers seem to be at the forefront of education in an ever-changing technical world

(Granito, Chernobilsky and Granito, 2012), enhancing the teaching method from all angles, such as the ability to interpret class materials, open the doors for creativity, and create a solid knowledge base that can be easily retained, as several studies have shown.

Moving from traditional attendance to school to e-learning will add more space, flexibility to student attendance. Adopt a self-drive learning approach and involve new teaching methods by concentrating on innovative aspects rather than saving all of the details and focusing on the critical facts to create a new thinker generation.

Discussion: Could we replace the teacher in the future?

As discussed earlier, the studies that represent the impact of the technology on knowledge retention and representing the value added to education explores one crucial question that needs to be discussed and answer in further research, which is " Could we replace the teacher in the future?"

The new technology will not replace the teacher. However, their role and teaching method will be changed from curriculum instructor to be more creative, instruct the machine and share their experience with the broader range of students worldwide to start from what they reach to collaborate to enhance the education sector and concentrate long-term knowledge retention.

V. CONCLUSION

In this paper, we concentrated on the use of emerging technology to aid students in learning general knowledge subjects and the effect of these technologies on knowledge retention rather than the conventional method. To provide a detailed summary of current studies and address the implications of the findings, we conducted a systematic literature review for research on information retention and the impact of technology use in education. Rather than memorizing information for an exam, teachers want their students to recall specifics for more than a week. Teachers are struggling to teach an ever-increasing amount of material.

The idea of interactive learning using Haptic Technologies, three-dimensional printing, Chatbots, interactive mining, and brain-based learning presented realistically has been shown in this study to increase students' understanding and comprehension abilities and revolutionize the teaching-learning process. Finally, each of the technologies addressed has its strength and weakness, which must be carefully examined and combined to create a teaching method with high knowledge retention value- added.

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Market-Basket Optimisation using Sales Pattern of Supermarket

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ABSTRACT

Finding association among numerous items that are related together can be challenging. At times such association may vary from individuals. Large supermarkets are often faced with such a puzzle which if well addressed can boost or adversely affect the business space, time and profit. In this study, the use of a priority algorithm has been applied using the market pattern of items that are sold as related item in big supermarket like Shoprite etc to optimize item arrangement. We implemented the approach of the algorithm in Python language with hypothetical sales pattern of items from such supermarket, we obtained support, confidence, and lift as criteria from the sales pattern that gave the association rules from the customers.

Keywords: association, optimize, support, confidence, lift.

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ABSTRACT

Finding association among numerous items that are related together can be challenging. At times such association may vary from individuals. Large supermarkets are often faced with such a puzzle which if well addressed can boost or adversely affect the business space, time and profit. In this study, the use of a priority algorithm has been applied using the market pattern of items that are sold as related item in big supermarket like Shoprite etc to optimize item arrangement. We implemented the approach of the algorithm in Python language with hypothetical sales pattern of items from such supermarket, we obtained support, confidence, and lift as criteria from the sales pattern that gave the association rules from the customers.

The results of the sales pattern can be applied to rearrange items in the big supermarket for improved packaging, faster sales and resource utilization of such market.

Keywords: association, optimize, support, confidence, lift.

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I. INTRODUCTION

Finding association among numerous items that are related together can be challenging. At times, such association may vary from individuals depending on choice. Large supermarkets having numerous goods to display on shelve may not know the best of arrangement on shelve that can showcase and meet with the interest of the buyers. Which product or combination of products to invest on so as to make maximum profit may not be clear. Large supermarkets are often faced with such puzzles which if well addressed can boost the business via space, time and profit management amidst other benefits. Market basket analysis is one of the techniques that can be used to discover association among items in large retailing (Babu *et al.,* 2021). It can reveal the relationships among entities in list of transactions. Market basket analysis can be used to compute product association to other products, arrange store and product layout for display array of items, decide market trends/inventory, predict future demands of product, formulate new market strategies, promote sales growth, develop merchants' marketing strategies, facilitate product promotion, product region division, slow down the loss and improve decision making etc (Kurniawan *et al.,* 2021; Alghanam *et al.,* 2022).

Market basket analysis is a form of data mining techniques. Data mining offers methods that can be used to explore meaniful information via its techniques that can be supervised and non-supervised.

Supervised machine learning method requires that data should be preprocessed and made to have instance labels (Osisanwo *et al.,* 2019). For a given sample output, some variables must have contributed to it and their respective contributions ultimately resulted to an output.

Learning with supervised machine algorithm might give weight according to size of the entire dataset and use that for estimation of co-efficients such that when a situation that has resemblance or variables identified as determinant, the result will be determined according to the co-efficient(s) of such determining variables during training.

Classification and predictive models are good examples of supervised learning. Examples of supervised learning models are Naïve Bayes Classifier, Perceptron, Support Vector Machine, Quadratic Classifiers, K-Means Clustering, Boosting, Decision Tree, Random Forest (RF); Neural Networks, Bayesian Networks, Linear Classifiers and Logistic Regression.

Using unsupervised learning method, the sample datasets usually cannot be arranged to determine any sample that will lead to output. Yet some methods are meant to mine association rules that exist in patterns of the dataset. Such rules can then be applied to subsequent future cases to determine the degree of association. Such learning methods are called unsupervised learning. Majority of text mining algorithms are examples of unsupervised learning method. Unsupervised learning algorithms can be used to recognize previously unknown patterns from dataset (Doersch *et al.,* 2015). It is similar to learning from the data itself and finding relation among different inputs and it is also possible not to have useful relationship among the inputs. If there is relationship, how strong are the relationships empirically? These represent the characteristics of unsupervised learning.

II. RELATED LITERATURE REVIEW

Agrawal et al (1993) invented the apriori algorithm for exploring and finding relations from the items in the database. The items in the database are usually represented in a relational form as tables. The items are used to form list of lists. Each combination of item alongside with another form can be used to form new list in which subsets can be generated and intersection is established. Danabhakyam and Punithavalli (2011) conducted study using Classification Dependent Predictive Association Rules (CPAR), Associative Classication, Classication Association Rule Mining (CARM), Distributed Apriori Association Rule, Six Sigma Technique and the Apriori algorithm and made comparism on each of the technique to detect their strength and weakness. The Apriori algorithm was found to be the best even though, it has some drawbacks.

E-commerce requires logistics to appropriately manage enormous client bases and develop long-term and profitable connections (Zineb *et al.,* 2021). This requires logistics to appropriately manage enormous client bases and develop long-term and profitable connections. This requires intelligent customer identification.

E-commerce represents “Big Data”, extracting knowledge from it can be challenging due to size. Approaches such as the use of analytical solutions to extract patterns knowledge and establish relationships can be worse. Therefore, association rule mining has been used (Qiu *et al.,* 2015).

Market basket analysis has been applied to diagnosis of patients to find relationship among symptoms of diseases to help improve diagnosis (Awodun and Adedara, 2017). The study used medical data inform of symptoms and diseases to detect the association between group of symptoms and disease. The rules generated in the study provided a method that measured joint frequencies for different symptoms and corresponding disease.

Association rule in data mining operation seeks to find connections among the features of a dataset. From the association rule, association analysis that seeks to study the features that are related to each other can be carried out. Association rule mining forms the basis of market basket analysis (Hamid and Khafaji, 2021). It can be carried out in two phases. In the first phase, all combination of items having support above the minimum support count are first treated. Those identified in the first phase are usually classified as frequent item sets that can be used to generate the desired rules. The association rule has both antecedent (if) and consequent (then). The antecedent represents an item found in the data while the consequent represents an item found in combination using the antecedent.

Formal definition of association rules

$$\text{Let } A = \{a_1, a_2, a_3 \dots a_m\} \text{ be set of items} \quad (1)$$

$$\text{Let } T = \{ t_1, t_2, t_3 \dots t_n\} \text{ be set of transactions} \quad (2)$$

Transaction t contains X, a set of items in A, if

$$X \sqsubseteq T \quad (3)$$

An association rule represents an implication of the form

$$X \Rightarrow Y, \quad (4)$$

where

$$X \subset T, \quad (5)$$

$$Y \subset T \quad \text{and} \quad (6)$$

$$X \cap Y = \emptyset \quad (7)$$

2.1 Properties of Apriori Algorithm

There are two important properties of Apriori algorithm which can be used to reduce the search complexity of the algorithm and the amount of computation involve in the mining process so as to concentrate on the needed frequent item sets. Firstly, suppose X is a frequent item-sets, it means all subsets of X are frequent itemset. Secondly, if Y is a non-frequent item-set, then all supersets of Y are non-frequent itemset. The steps involve in the Apriori algorithm are shown below

2.2 Apriori Algorithm

Input: Transaction Database, min support, min Confidence
Output: Support, Confidence, Lift

Step 1: Tabulate items in database to form list
Step 2: Start with itemsets containing just a single item
Step 3: Formulate list of each item and obtain frequency
Step 4: Compute the support for itemsets
Step 5: Using the itemsets from Step 1, generate all possible itemset combinations.
Step 6: Repeat steps 1 - 4 until there are no more new itemsets.
Step 7: Keep the itemsets that meet the minimum support threshold and remove itemsets that do not support minimum support
Step 8: Extract all the subsets having higher value of support than minimum threshold.
Step 9: Select all the rules from the subsets with confidence value higher than minimum threshold.
Step 10: Order the rules by descending order of Lift.

III. PERFORMANCE EVALUATION

The three Major Components of association rule mining are support, confidence and lift.

Support: Refers to the default popularity of an item and can be calculated by finding number of transactions containing a particular item divided by total number of transactions.

$$\text{Support(A)} = \frac{Transactions\ containing\ (A)}{Total\ Transactions} \quad (8)$$

Confidence is an index of reliability of the association rule. Confidence refers to the likelihood that an item B is also bought if item A is bought. It can be calculated by finding the number

of transactions where A and B are bought together, divided by total number of transactions where A is bought.

$$\text{Confidence}(A \rightarrow B) = \frac{(Transactions\ containing\ both\ (A\ and\ B))}{(Transactions\ containing\ A)} \quad (9)$$

Lift(A -> B) refers to the increase in the ratio of sale of B when A is sold. Lift(A –> B) can be calculated by dividing Confidence(A -> B) divided by Support(B).

$$\text{Lift}(A \rightarrow B) = \frac{(Confidence\ (A \rightarrow B))}{(Support\ (B))} \quad (10)$$

The dataset used in this study contains the record of transaction of customers in a supermarket including the names of various items purchased by the customers. There are twenty different products and seven thousand five hundred transactions [https://raw]. The apriori algorithm was used to convert the items into list, extract frequent item set and find subsets that meet up with minimum support count, we were able to obtain various lists such as the number count for all items. The screen shot is shown in Figure 1.0. The sample count is shown in Figure 1.1. We were also able to use the model to obtain the association of items containing 2 items, three, four etc. Figure 1.2 shows the sample results obtained using association rule containing 2 items. While Figure 1.3 shows the confidence, support and lift obtained from the model. We vary the support probability from 0.01 to 0.15 and obtain the plot for execution times. The plot is shown in Figure 1.4. The figure shows the reduction in execution time as the support value increases, there is reduction in the number of association rule because of increasing value of support.

	items	incident_count	all
0	mineral water	1787	all
1	eggs	1348	all
2	spaghetti	1306	all
3	french fries	1282	all
4	chocolate	1230	all
...	...	...	...
115	bramble	14	all
116	cream	7	all
117	napkins	5	all
118	water spray	3	all
119	asparagus	1	all

Figure 1.0: Association Rule for Two Item Sets

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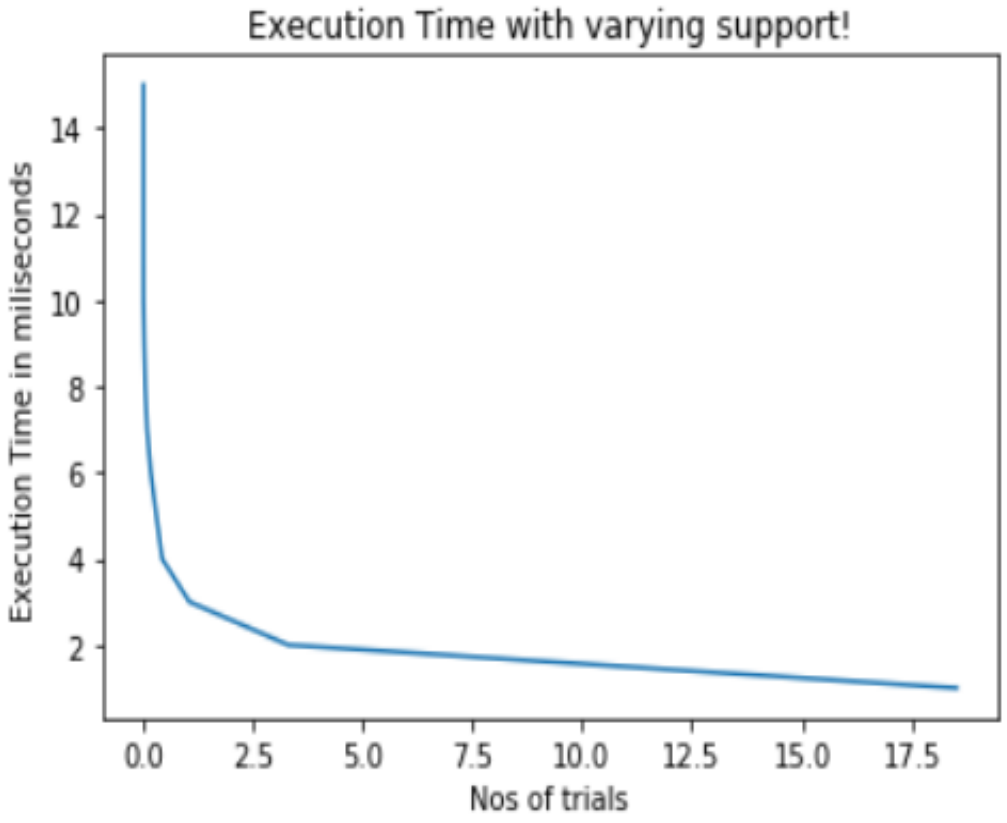
	support	itemsets	length
23	0.059573	(, a)	2
27	0.080373	(, e)	2
34	0.056340	(, n)	2
36	0.072653	(, r)	2
38	0.056087	(t,)	2
45	0.093927	(e, a)	2
51	0.052973	(l, a)	2
53	0.849033	(n, a)	2
56	0.052827	(r, a)	2
57	0.055747	(s, a)	2
58	0.075867	(t, a)	2

Figure 1.1: Association rule for two item sets

	antecedents	consequents	antecedent support	consequent support	support	confidence	lift	levera
64885	(o, r, b, , n)	(g, e, f)	0.011547	0.010707	0.010360	0.897229	83.800931	0.0102
64978	(g, e, f)	(o, r, b, , n)	0.010707	0.011547	0.010360	0.967621	83.800931	0.0102
64912	(g, e, r, f)	(, n, o, b)	0.010707	0.011547	0.010360	0.967621	83.800931	0.0102
47910	(, n, o, b)	(g, e, f)	0.011547	0.010707	0.010360	0.897229	83.800931	0.0102
64951	(, n, o, b)	(g, e, r, f)	0.011547	0.010707	0.010360	0.897229	83.800931	0.0102
...	...	...	...	...	...	...	...	
1237	(g)	(c, e)	0.066073	0.061507	0.010053	0.152154	2.473783	0.0059
2315	(t, l)	(s)	0.042880	0.098067	0.010147	0.236629	2.412944	0.0059
6901	(t, l, a)	(s)	0.042880	0.098067	0.010147	0.236629	2.412944	0.0059
2318	(s)	(t, l)	0.098067	0.042880	0.010147	0.103467	2.412944	0.0059
6910	(s)	(t, l, a)	0.098067	0.042880	0.010147	0.103467	2.412944	0.0059

Figure 1.0: Support, Confidence and Lift



IV. CONCLUSION

Databases are used in storing transaction records in form of relational databases in many supermarkets. Physical attempt to mine useful patterns out of such transactions can be difficult and time consuming, but useful patterns of information can be obtained through the use of association rules for illustrating the relationships in the database. This study has applied the association rules and provided various answers to queries that can be used to boost decision making in supermarkets with large number of items and customers alongside with execution time of such results of the decision. The study showed that large supermarkets have a lot to benefit using the association rule.

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Towards a Taxonomy of Services Offered by Start-up Business Incubators

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ABSTRACT

Incubators are becoming increasingly important in today's business world. Incubators are a place where ideas are developed into businesses with the potential to grow and become viable. Incubators had evolved from earlier days when it was predominantly offered in the form of business support to the current model where various elements of success are included in the incubator services. These incubators differ in their types, business model, as well as areas of expertise. The current study focuses on assessing the services offered by start-up business incubators. The focus is on services offered such that the success of the businesses is made possible, and the viability of the business is also improved. The aim of the study was to propose a service framework that can be used to assess the effectiveness of the incubators. The proposed services framework was to consider the current stiff competition for new businesses to stay afloat. After conducting a literature review, seven services were identified. These services lay within business development, mentorship, expertise, as well as partnerships that could bolster any start-up to success. Three University Business Incubators were then selected within the United States for assessment of the application of the identified seven services into their frameworks. Results indicated that much still needs to be done in areas of expertise, partnerships, and future connections to funding for the University Business Incubators to start realizing the full benefits of being in operation.

Keywords: university business incubator, incubator, entrepreneurship, companies.

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Towards a Taxonomy of Services Offered by Start-up Business Incubators

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ABSTRACT

Incubators are becoming increasingly important in today's business world. Incubators are a place where ideas are developed into businesses with the potential to grow and become viable Incubators had evolved from earlier days when it was predominantly offered in the form of business support to the current model where various elements of success are included in the incubator services. These incubators differ in their types, business model, as well as areas of expertise. The current study focuses on assessing the services offered by start-up business incubators. The focus is on services offered such that the success of the businesses is made possible, and the viability of the business is also improved. The aim of the study was to propose a service framework that can be used to assess the effectiveness of the incubators. The proposed services framework was to consider the current stiff competition for new businesses to stay afloat. After conducting a literature review, seven services were identified. These services lay within business development, mentorship, expertise, as well as partnerships that could bolster any start-up to success. Three University Business Incubators were then selected within the United States for assessment of the application of the identified seven services into their frameworks. Results indicated that much still needs to be done in areas of expertise, partnerships, and future connections to funding for the University Business Incubators to start realizing the full benefits of being in operation.

Keywords: university business incubator, incubator, entrepreneurship, companies.

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I. INTRODUCTION

An incubator can be thought of as a place where new businesses (henceforth referred to as start-ups) are helped to bring their ideas full-term and form viable business ventures. In theory, the term 'incubator' has been used about the activity taking place within the incubator facility. For instance, (Bergek and Norrman, 2008) referred to incubators as a tool that promotes the development of technology-based firms. (Allen and Mccluskey, 1991) elaborates further by giving a glimpse into what the incubator offers by stating that it is a facility where shared office services, affordable space, and assistance in business development are offered in an environment that is conducive to the creation of new ventures and support for their early-stage growth and survival.

Of importance to note within the definitions is that the incubators support start-ups in a bid to help them grow. (Cooper, 1985) emphasizes the incubator's role in the growth of new ventures by stating that incubators act as mentors in helping entrepreneurs start and grow businesses that, in some instances, were similar to the incubator organization hosting them. In other cases, which tended towards software development and technology, the start-ups were found to have operations and ideas that were not similar to the incubator organization, but by being in the incubator, the start-ups benefited from the technical and marketing expertise needed in running their business ventures in the absence of prior experience. Hence, from these definitions, the overall goal of incubators is to help start-ups

obtain the necessary business expertise needed to set up and grow a business venture.

The current business environment is permeated with incubators. This increase is, in retrospect, in response to the success of start-ups within the technology sphere such as Facebook, Twitter, and Instagram, which inspired the younger generation to join the technology bandwagon through start-ups, wishing to gain the same 'overnight' success as the young technology companies. These start-ups have, in most cases, been grown within incubators. Incubators, as noted in (Li et al., 2020), have also increased in numbers in recent years owing to the need for having new businesses that support economic growth in most countries.

These incubators are funded not just by private organizations and businesses but also by governments. While it is economically sound to support these start-ups to minimize unemployment, it is also still necessary to evaluate their effectiveness. (Harper-Anderson and Lewis, 2017) noted that the quality of the incubator plays a major role in the success of the start-ups it supports.

For instance, incubator qualities such as services offered, management practices, and resources are termed as key indicators determining the success of an incubator. According to (Harper-Anderson and Lewis, 2017), the services offered include legal services, help in accessing funds, shared office equipment, business plan development, and opportunities to network. The author further noted that management practices such as human capital and the manager's skill and competence level were all necessary for making the incubated start-ups a success. Not just these but also the opportunity to work was noted as crucial in helping build a network that can bolster the start-up forward in terms of resources. These networks include legal experts, financial advisors, elected officials, experts in economic development, and business leaders. Hence, it can be said that the internal quality of the incubators determines the outcomes of the businesses incubated in them.

Another question that may be asked regarding incubators is: what type of selection criteria do they use in admitting start-ups? (Thierstein and Willhelm, 2001) Give a brief description of what might be used as a selection criterion by investigating how the incubating services were offered. The authors noted that a majority of the incubators investigated (in Switzerland) operated within manufacturing, development activities, and services. Also, the facilities were offered on a space-to-rent basis, with a high-tech input level utilized. From this study, the major observation is that the types of start-ups supported must be within the three-given categorized: service, manufacturing, and development activities.

(McAdam and McAdam, 2008) also investigated the use of University Science Park Incubators in the development of High Technology Business Firms (HTBF) in respect to the lifecycles of the HTBF. Just a glimpse into this study also indicates that the incubators are specific as to which start-ups they accept for incubation, based on their business function, for instance, whether they are manufacturing, technology, or service-oriented. This notion is supported in (von Zedtwitz and Grimaldi, 2006), who noted that incubators could be categorized based on four elements of competitive scope: segment scope, vertical scope, industry focus, and geographic focus; as well as their distinct strategic objectives (whether for-profit or not for profit).

Segment scope allows for incubators to generate start-ups based on distinct sources, such as from universities, industries, or corporations. The geographic scope allows incubators to focus on geographic regions that have potential in networking, meaning that where most businesses are concentrated is where the incubator will be situated. Industry focus helps the incubators support the start-ups through expertise in the incubator manager's field of specialization, which is important in imparting knowledge to the start-up founders. From these studies, it can be deduced that different models are adopted by the different incubators in providing their services to start-ups.

This paper aims at investigating the various archetypes used in implementing incubators and

attempt to formulate a framework that can be used in defining best practices applicable to incubators. At least five incubators will be investigated, with their characteristics and distinctions observed to highlight the key functionalities, models, and structures used in implementing the incubators about the services offered to the start-ups.

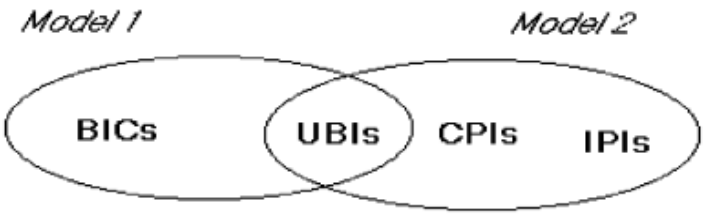
This paper is structured in this way:

- Section 2 will discuss the various incubator archetypes in terms of their characteristics, as discussed in (von Zedtwitz and Grimaldi, 2006).
- Section 3 will outline the characteristics for creating the framework proposed in this study.
- Section 4 will discuss the methodology used in collecting, analyzing, and presenting the data.
- Section 5 will discuss the results of the data collection, as well as the application of the framework proposed in section 3.
- Section 6 will conclude the study.
- Section 7 will give recommendations for improvement in future research.

II. INCUBATOR ARCHETYPES

According to von Zedtwitz and Grimaldi (2006), differentiated incubators are based on four major factors, as well as the basis for conducting business (for-profit or non-profit). This differentiation is what makes for the archetypes used in describing the activities and services behind certain incubators. These archetypes are different from the description given in (von Zedtwitz and Grimaldi, 2006), and features mainly the segment scope from among the four competitive scopes defining the number of value chains a business engages in. (Barbero et al., 2013) used four archetypes to describe how some incubators fulfill the segment scope: the university incubator, basic research incubator, private incubator, and economic development incubator. (Sansone et al., 2020) described a different type of incubator, the social incubator, which focuses on start-ups that have significant social impacts, while (Peters, Rice, and Sundararajan, 2004) described incubators based on their business models: for-profit and not-for-profit. For-profit incubators involve start-ups relinquishing part of their equity to the funding organization, while not-for-profit incubators, which are mostly affiliated to universities or government agencies, do not require the start-ups to part with their equity.

How one start-up selects one model from the other depends on which one serves its purpose. (Grimaldi and Grandi, 2005) focused on incubator types based on four categories: University Business Incubators, Business Innovation Centers, Corporate Private Incubators, and Independent Private Incubators. From these four categories were found two models under which they operated. The model is illustrated in Figure 1 below:



Source: (Grimaldi and Grandi, 2005)

Figure 1: Business Model from the convergence of four categories of incubators

As the figure illustrates, the two models are a derivative from the convergence of the four incubator categories. This convergence is based on the concept of the derivative, where each of the named incubators can make use of the best of what the other incubators provide, merge with their own, and realize new and better business models. However, this proposed business model is

not in effect but a suggestion for improving on the weaknesses presented by the four named incubator types (Hansen, Nohria, and Sull, 2000).

Also investigated the success of incubators and found that only a specific category of incubators outshines the others; the networked incubator. What distinguished the networked incubator from all the other incubators, as (Hansen, Nohria, and Sull, 2000) noted, was the presence of a mechanism through which partnerships could be fostered with other businesses to allow for a flow of knowledge and talent between the incubator firm and already established businesses.

It is this networking that connects the start-ups to the resources they need, enabling them to move faster than the start-ups that lack a network. Importantly, (Hansen, Nohria, and Sull, 2000) noted that when the networked incubator, when properly implemented, would bring together the scope and scale of large, established organizations and the spirit of entrepreneurship characterized by small venture-capital firms. In conclusion, the authors noted that it is the networked incubator model that suits the current economy that requires wealth and value creation. Another 'hybrid' incubator is presented in (Phan, Siegel, and Wright, 2005), who observed that science parks and incubators, though they exist in incubating start-ups, have no particular systematic framework that can help in understanding them and their dynamic nature, the nature of the start-ups incubated in them, and the level of success that can be attributed to them.

In all the above literature, it is observed that there are multiple types of incubators in place, each with its unique services and business model to help in delivering these services. The literature has made attempts at highlighting their operations and structures but has failed to offer insights as to their operations and performance. In this light, a gap is observed to exist. The following sections of this investigation will attempt to fill the gap by focusing on the only type of incubator category, the university business incubator, in terms of its performance.

2.1 University Business Incubator

University Business Incubators, as mentioned in (Grimaldi and Grandi, 2005), are public incubators mostly supported by governments to aid in research into ideas that can become viable businesses in the future. The research areas tend towards science and technology, with the universities lending the government talent, faculty time, and resources necessary for the undertaking of the research. (Mian, 1996) further noted that the University Business Incubator is a strategy used by governments to promote the development of new research and technology-based firms. (Somsuk and Laosirihongthong, 2014) extrapolated more on the operations of University Business Incubators through analyzing enabling factors that contribute to their success, specifically focusing on their internal factors.

These internal factors were identified as human, financial, technological, and organizational resources. The investigation highlighted that human resources ranked higher among the four enabling factors, followed by financial resources, organizational resources, and technological resources, in that order. Human resource factor, as explained in (Somsuk and Laosirihongthong, 2014), factors in the founding team's attributes, the business incubator's management team, and the start-up's team whose talents and expertise are needed for the success of the incubation. (Kiani Mavi et al., 2019) conducted a study that can add more weight to the findings (Somsuk and Laosirihongthong, 2014). (Kiani Mavi et al., 2019) ranking factors that impact the strategic management of University Business Incubators. The highest-ranked factor was talent managers. Generally, talent managers utilize the full spectrum of human resource practices in attracting, recruiting, onboarding, motivating, and retaining top-performing employees. The high ranking means that within the investigated University Business Incubators, the effective managing of human resources was an essential factor contributing to the success of the incubators. Hence, it can also be said that talent within the incubators is the key to success, given that it is the student's creativity and critical thinking that will develop solutions required to

solve today's problems in science and technology. A pertinent question raised on the effectiveness of the University Business Incubators is presented in (Bennett, Yábar, and Saura, 2016).

The main argument behind this questioning is that since the government and other private institutions fund the University Business Incubators, there should be some evidence to show that the goals of these incubators are met (Bennett, Yábar, and Saura, 2016). The investigation highlighted that there was little done in terms of assessing the effectiveness of the University Business Incubation. Examples are given from other literature that indicated that while there were a few success stories from University Business Incubators, there was still a lack of clarity or proof of the cost-effectiveness and value addition of firms coming from the University Business Incubators. (Mian, 1996a) presented a different perspective on the issue of value addition, looking at it from the incubator role in providing the needed resources to the start-ups hosted within University Business Incubators. (Mian, 1996a)'s perspective included value-added dimensions of the incubator services provided, university image, student employees, and laboratories and equipment all contributed to value creation within the UBIs. Hence, the effectiveness of the UBIs is still fertile ground for further investigation.

III. PROPOSED INCUBATOR SERVICES FRAMEWORK

It is observed from the literature that the incubators are formed based on the objectives of the incubator firms, which is also the single most important factor in starting an incubator. For instance, if a firm works within medicine, then the incubator it is likely to start is one geared towards medicine since it is the area of expertise. Other factors noted to influence incubators include funding, geographic region, and industry. This study has also highlighted that the University Business Incubator is one of the incubators included among the incubator implementation models. The UBI was selected for this study specifically as an anchor for the other incubators, given that their environment and goals tend to foster collaboration and are teeming with knowledge and talent that may be absent from other incubators (Hassan, 2020). Hence, the UBI is used as a guide in the effective implementation of an incubator service framework.

The framework is developed based on an extensive review of the literature to highlight the different services offered by incubators, which were then scrutinized for applicability in other areas and not just added to a comprehensive list. Table 1 below highlights the identified services, along with their importance.

Table 1: Proposed Incubator Services Framework

No	Service	Service description
1	Office space and administrative services	The start-up team would need to work together under one roof during the initial stages. Being less than one roof ensures speedy feedback and collaboration. Office administrative services include access to the internet, printers, coffee, meeting rooms, drawing boards, and equipment that will facilitate working on the start-up project.
2	Networking activities	Networking, as highlighted in the literature, is crucial for the speedy progress of a start-up. The network will provide the resources needed by the start-up to help accelerate it to the next level.
3	Mentorship	Mentors have been through a certain path and are aware of pitfalls to be avoided and opportunities to be taken. Having a mentor will bridge the lack of experience gap that is sometimes common with most start-ups
4	Connections to future capital	Most start-ups need capital to scale their business. Having future sources of capital can help in this case.
5	Partnership opportunities	Partnerships can be the ticket to a start-up's connection to larger market segments. Hence, having opportunities for partnerships is important to include among the services in incubators.

6	Expertise	Expertise can be in the form of training, business and legal advice, knowledge transfer, technical support, as well as skills acquisition that can help fill weak areas within the start-up.
7	Business development programs	These programs are geared towards making the business better in terms of growth. Workshops and discussion panels may be possible areas to include within the business development program.

Source: Primary

The services included in Table 1 were viewed in terms of applicability to a wide range of incubators of varying industries, scopes, and goals. It was thought that it might not be possible to include every service being offered by each of the different incubators. It was also premised that finding services that can resonate with every business, and not just the start-ups within incubators, was the key to selecting the services to include in Table 1 above. Hence, Table 1 has considered studies such as Wiggins and Gibson (2003), Salem (2014), and Albort-Morant and Oghazi (2016) in making the list of services to include in incubators.

IV. METHODOLOGY

4.1 Design

A research design is the techniques and methods used by the researcher in conducting an investigation. An empirical study has been selected as the research design for us in this case.

The empirical study included selecting at least three prominent University Business Incubators, highlighting the key services and strategies used in implementing the incubator, and comparing these with the proposed framework in Table 1 above. This comparison was conducted as a way of analyzing how effective the services provided in these incubators were in meeting the needs of the start-ups within the incubators, based on the proposed framework.

The University Business Incubators were selected based on their geography, i.e., located within the United States. The selection criteria included factors such as having an internet presence and the services offered well described on their website since the information was being gathered firsthand from their websites. Opinions from former and current start-ups were also gathered as a way of corroborating what is presented on the UBI websites.

4.2 Selected UBI Characteristics

The three selected incubators were American University Entrepreneurship Incubator, the Startup Aggieland at Texas A&M University, and the Start-up Garage at the Center for Entrepreneurial Studies at Stanford University.

American University Entrepreneurship Incubator is a University incubator that focuses on building entrepreneurial innovations and bringing them to market. Entrepreneurial courses have been taught in this school since 1980 and have grown to currently include about 300 students enrolled annually in different entrepreneurship classes.

Notable companies to spring from this incubator include UPace, a company that seeks to connect recreational facilities with clients to improve their mental and physical wellbeing.

The Startup Aggieland at Texas A&M University is a public business school in Texas. Startup Aggieland incubator is implemented as a start-up incubator, with an environment described as being open and collaborative. The incubator admits not just students but also entrepreneurs, staff, and faculty, who come together to work on their business ideas. Notable start-ups springing from this incubator include GoFresh, an online company that focuses on preparing and delivering healthy foods to its clients.

The Start-up Garage at the Center for Entrepreneurial Studies at Stanford University describes itself as 'an intensive, hands-on, project-based course where student teams design and test new business concepts that address real-world needs. The incubator website states that there have been more than 130 companies founded by its alumni, and over 2.5 billion dollars have risen for funding by the alumni to date. Notable companies to spring from this incubator include Instagram, an online photo and video

sharing application that is used by thousands of people worldwide.

V. RESULTS

Results of the comparison between the university incubator services and the proposed framework are presented in Table 2 below. The 'X' is used to mark the services that the UBI incubators have that agree with the framework.

Table 2: Comparison of Incubator services against the proposed framework

Incubator	Services						
	Office space and administrative services	Networking activities	Mentorship	Connections to future capital	Partnership opportunities	Expertise	Business development programs
American University Entrepreneurship Incubator	X	X	X	X			X
The Startup Aggieland at Texas A&M University	X		X	X		X	
The Start-up Garage at the Center for Entrepreneurial Studies at Stanford University	X					X	X

Source: Primary

The results of the comparison have highlighted that the American University Entrepreneurship Incubator has most of the proposed framework services in their incubator. Only two services: partnership opportunities and expertise, are missing. However, these two are noted to mainly impact the incubator on issues such as marketing and leveraging the start-ups, as well as on individual areas that the start-ups may be weak. The Startup Aggieland at Texas A&M University followed with at least four of the proposed framework services in place. The missing services: networking activities, partnership opportunities, and business development are noted to impact the incubator on factors such as tapping into existing markets, speeding up the start-up going into the market and obtaining resources, as well as a chance to gain knowhow of how to grow the business.

The Start-up Garage at the Center for Entrepreneurial Studies at Stanford University had the least of the proposed services within the framework. Areas that missed the attention of this incubator included networking opportunities, mentorship, connections to future capital, and partnership. These services are viewed to impact the start-ups on the part of scaling, exposure, and market reach. Hence, the UBI investigated here has highlighted that different incubators, even those in the same industry, have different ways of implementing their incubator business models to meet the needs of their budding entrepreneurs.

VI. DISCUSSION

At least seven services were identified in the framework that was deemed critical to include among the services provided by incubators. All of the incubators had the basic: office space and administrative services that are common among all other incubators. However, the rest of the other factors are what can differentiate one incubator from another. Mentorship, for instance, gives entrepreneurs a chance to be guided by someone familiar with their area of interest.

A lot of mistakes and missed or miscalculated opportunities can be avoided by having a mentor. Business development is also another crucial service that can help start-ups better prepare for the growth of their businesses, moving from one point to the next. Opportunities to create partnerships are also noted to be crucial in that it opens existing markets to the start-ups, making it easier to scale at a much higher speed. Connections to future capital are also necessary where the start-ups wish to scale or when they move from the incubator to the real world and need funds to set up offices. Expertise is also crucial where the application of specialized skills is required, such as technical skills. Hence, from this comparison analysis, it can be deduced that the university business incubators still have room for improving their business models for more success to be obtained from their incubation services.

VIII. CONCLUSION AND FUTURE STUDIES

Incubators have become important elements within the business sphere today. The current companies that have been in place for years are not enough to support the growing number of youths seeking jobs; hence, creativity must be used. Governments and private institutions support these incubators through funding. Incubators are noted to be implemented through different categories, which can broadly be classified based on four competitive scopes: industry, geographic, segment, and vertical scopes. The university business incubator was investigated in this paper, with results indicating that much still needs to be done for a comprehensive list of services to be offered in these institutions. This investigation focused on highlighting the services offered in these institutions through checking their online websites for a list of the services offered. This method is noted to be insufficient, given that more details would have been obtained if the institutions had been given interviews. However, due to the current pandemic, it was not possible to meet with the concerned parties. Hence, it is recommended that a future follow-up investigation be conducted, this time while meeting with the incubators, for better insights to be obtained.

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Calculation of Elements Taking into Account Geometric and Physical Nonlinearity by the Method of Central-Defined Deformations

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Adyshev Osh Technological

ANNOTATION

This article describes the use of multi-storey buildings and structures, which are one of the new promising areas. The use of prefabricated reinforced concrete, in comparison with full monolithic, dramatically reduces the labor intensity of work at the construction site. The prefabricated monolithic structure during the construction of statically indeterminate systems makes it possible to quite simply ensure the spatial rigidity of the building or structure as a whole, as well as to reduce the construction time in comparison with a complete monolith by several times, reduce the labor intensity of the production of works by about 1,5÷2 times and accordingly, the value of the object decreases. Plane and bending stress states are experienced by many structures of high-rise construction.

Keywords: calculation model, carrier systems, deformation, voltage, bend, stretching, geometric and physical nonlinearity.

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Calculation of Elements Taking into Account Geometric and Physical Nonlinearity by the Method of Central-Defined Deformations

Расчет элементов с учетом геометрических и физических нелинейности методом сосредоточенными деформациями

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I. ANNOTATION

This article describes the use of multi-storey buildings and structures, which are one of the new promising areas. The use of prefabricated reinforced concrete, in comparison with full monolithic, dramatically reduces the labor intensity of work at the construction site. The prefabricated monolithic structure during the construction of statically indeterminate systems makes it possible to quite simply ensure the spatial rigidity of the building or structure as a whole, as well as to reduce the construction time in comparison with a complete monolith by several times, reduce the labor intensity of the production of works by about 1,5÷2 times and accordingly, the value of the object decreases. Plane and bending stress states are experienced by many structures of high-rise construction. These are beams - walls, and bracing systems, in which horizontal loads are perceived mainly by diaphragms and stiffening cores. There are various methods for solving problems for a plane and bending stress state, for example, the finite difference method, the finite element method, the limit equilibrium method and the method of concentrated deformations. The relevance in this work lies in the need to create a methodology for calculating reinforced concrete structures in multi-storey buildings and structures, based on the method of concentrated deformations (MSD) with implementation on computer technology, taking into account the influence of the expansion effect and real diagrams of deformation of concrete and reinforcement, at different loading times. It also describes in detail the formation of a flat and bending model for the analysis of reinforced concrete structures by the method of concentrated deformations, with a complete diagram of the deformation of concrete and reinforcement, taking into account geometric and physical nonlinearity, including a descending branch depending on the initial data. In addition, a comparison of the obtained results of analytical, theoretical and experimental research data is given.

АННОТАЦИЯ

В данной статье описано использование многоэтажных зданий и сооружений, которые являются одним из новых перспективных направлений. Применение сборного железобетона по сравнению с полно

монолитным резко снижает трудоемкость работ на строительной площадке. Сборно-монолитная конструкция при возведении статически неопределимых систем позволяет достаточно просто обеспечить пространственную жесткость здания или сооружения в целом, а также в несколько раз сократить сроки возведения по сравнению со сплошным монолитом, снизить трудоемкость производства работ примерно в 1,5÷2 раза и, соответственно, снижается стоимость объекта. Плоские и изгибные напряженные состояния испытывают многие конструкции высотного строительства. Это балки-стены и системы связей, в которых горизонтальные нагрузки воспринимаются в основном диафрагмами и ядрами жесткости. Существуют различные методы решения задач для плоского и изгибного напряженного состояния, например, метод конечных разностей, метод конечных элементов, метод предельного равновесия и метод сосредоточенных деформаций. Актуальность данной работы заключается в необходимости создания методики расчета железобетонных конструкций многоэтажных зданий и сооружений, основанной на методе сосредоточенных деформаций (МСД) с реализацией на вычислительной технике учета влияния расширения влияние и реальные диаграммы деформирования бетона и арматуры при различных временах нагружения. Также подробно описано формирование плоской и изгибной модели для расчета железобетонных конструкций методом сосредоточенных деформаций, с полной диаграммой деформирования бетона и арматуры с учетом геометрической и физической нелинейности, в том числе нисходящей ветвь в зависимости от исходных данных. Кроме того, дано сравнение полученных результатов аналитических, теоретических и экспериментальных данных исследований.

II. ВВЕДЕНИЕ

В монолитных многоэтажных зданиях и сооружениях, является одним из новых перспективных направлений, его объемы строительство в которых растут год за годом. Применение сборно-монолитного железо-бетона по сравнению с полным монолитным резко снижает трудоемкость производства работ на строительной площадке, исключается работа по устройству поддерживающей опалубки. Сборно-монолитная конструкция при возведении статически неопределимых систем позволяет довольно просто обеспечить пространственную жесткость здания или сооружения в целом, а также сократить сроки строительства по сравнению с полным монолитом в несколько раз, снизить трудоемкость производства работ порядка в 1,5÷2 раза и соответственно уменьшается стоимость объекта.

В многоэтажных гражданских и общественных зданиях элементы проявляют объектом ориентирования на расчетные и опытные исследования. Анализ таких обследований представляет, что у них много общего в части исходных положений, однако они различаются способом реализации. В них можно выявить общую постоянную тенденцию с использованием компьютерной технологии и усовершенствованием расчетных программ и алгоритмов [1 - 12, 14, 15].

Актуальность работы заключается в необходимости создания методики расчета плит перекрытий, опертых по контуру в монолитных многоэтажных зданиях, на основе метода сосредоточенных деформаций (МСД) с реализацией на вычислительной технике, учитывающие влияние эффекта распора и реальные диаграммы деформирования бетона и арматуры, при различных длительностях нагружения.

III. МЕТОДИКА

Расчет несущей способности, согласно [16], рассчитывает в нормальных сечениях величины внешних сил, основываются на условной схеме распределения напряжений и деформаций в бетоне и арматуре по сечению. Расчет по образованию нормальных трещин производится, исходя из положений,

непохожих на расчет несущей способности и опытно обоснованных данных.

Расчет железобетонных элементов, объединенных податливыми связями, может выполняться методом сосредоточенных деформаций, методика детально дано в следующих трудах [2 - 10].

Напряженно-деформированное состояние железобетонных плит выражается матричным уравнением вида

$$[R]\cdot\upsilon\} = \{P\} \qquad (1)$$

где: [R] - матрица внешней жесткости системы;
{υ} - вектор искомых перемещений элементов МСД;
{P} - вектор узловых нагрузок.

Глобальную нумерацию элементов МСД и связей метода перемещений для всей системы целесообразно вести по длинному направлению (в данном случае длина-ширина-направо), при такой нумерации число элементов рассчитываемой конструкции в длинном направлении будет m, а коротком n, тогда ширина ленты составить 6·m·n.

Связь между внутренними усилиями по плоскостям сосредоточенных деформаций и соответствующи мидеформациями записываются в виде.

$$\{F\} = [Э]\cdot\{\lambda\} \qquad (2)$$

где: {F} - вектор внутренних усилий;
[Э] - матрица внутренней жесткости сечений;
{λ} - вектор сосредоточенных деформаций (взаимных

смещений и поворотов элементов МСД).
Для всех сечений элементов МСД по плоскостям сосредоточенных деформаций принимается гипотеза плоских сечений.

Система алгебраических уравнений (1) решается относительно вектора перемещений {υ}. Для этого должны быть известны матрица внешней жесткости [R] и вектор узловых нагрузок {P}.

Имея расчетную модель, без особых затруднений можно составить вектор внешних сил {P}. Основная трудность заключается в формировании матрицы внешней жесткости системы [R]. Для ее построения можно применить способ единичных перемещений элементов МСД в направлении наложенных связей. Однако, как показала практика, удобнее воспользоваться формулой

$$[R] = [A]\cdot[K]\cdot[A]^{т} \qquad (3)$$

где: [A] - матрица, коэффициентов уравнений равновесия элементов МСД;
$[A]^{т}$ - матрица, транспонированная с матрицей коэффициентов уравнений равновесия [A];
[K] - матрица внутренней жесткости сечений.

Согласно формуле (2) связь между внутренними усилиями по плоскостям сосредоточенных деформаций и соответствующими деформациями для типового к - го элемента МСД запишем в матричном виде (рис. 1):

$$\{F\}_k = [Э]_k\cdot\{\lambda\}_k \qquad (4)$$

где: $\{F\}_k$ - вектор внутренних сил по граням к - го элемента
по плоскостям сосредоточенных деформаций;
$[Э]_k$ - матрица жесткости сечений для к - го элемента
по тем же граням;

$\{\lambda\}_k$ - вектор соответствующих деформаций.

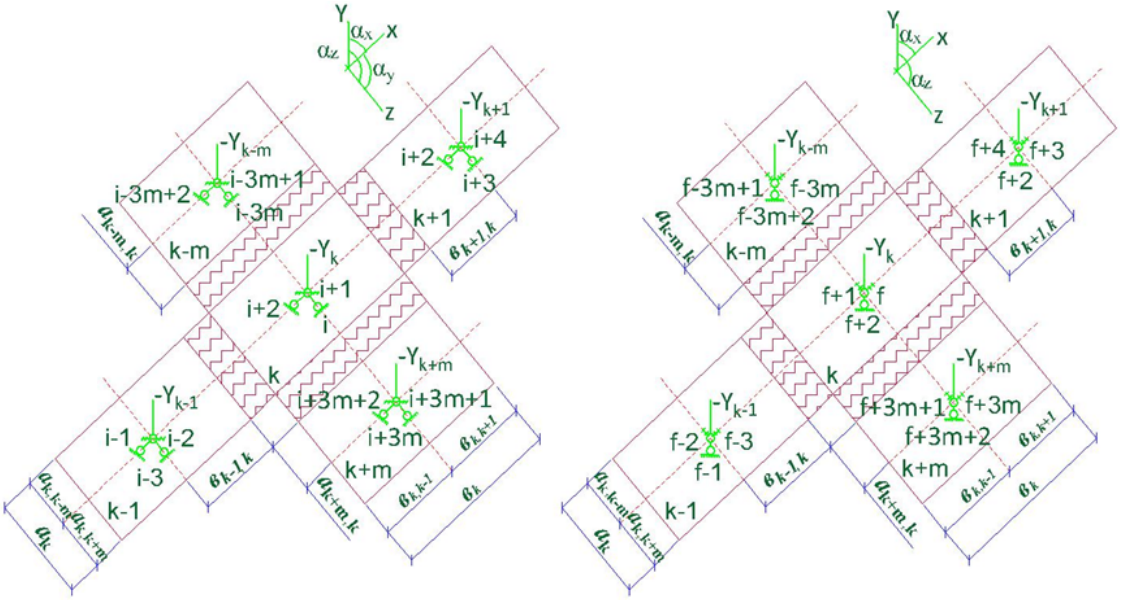

Рис. 1: Изгибаемая плита, связи метода перемещений для плоского и изгибного напряженного состояния

Настоящие исследования по улучшению расчетов элементов ведутся по некоторым условиям, выделяющихся признаками:

- использование в расчетах полных диаграмм деформирования «для одноосного сжатия и растяжения бетона и арматуры при различных режимах работы»;
- объединение расчетов сечений с выявлением внутренних сил в статически неопределимых системах;
- применение в расчетах компьютерной технологии.

Остановимся на отдельных из сформулированных условий.

В данной работе железобетонные элементы имеют отдельные признаки и основываются на соответствующие положения:

- продольные деформации бетона и арматуры в сечениях на всех ступенях нагружения разделяют по закону плоского деформирования;
- продольные деформации и надлежащие им нормальные напряжения в бетоне и арматуре получаются «средними»;
- сечения элемента может быть любой формы – прямоугольник, круг, двутавр, швеллер и т.д. (рис. 2).

Закон о распределении продольных деформаций в бетоне и арматуре по закону гипотезы плоских сечений для напряженно-деформированного состояния является спорным. Однако работа в стадии до образования трещин, что и принято в работах [16], что является справедливой и для стадии после образования трещин, но в сечениях между трещинами и в сечениях прямо по трещине; в других участках конечно искривление сечений.

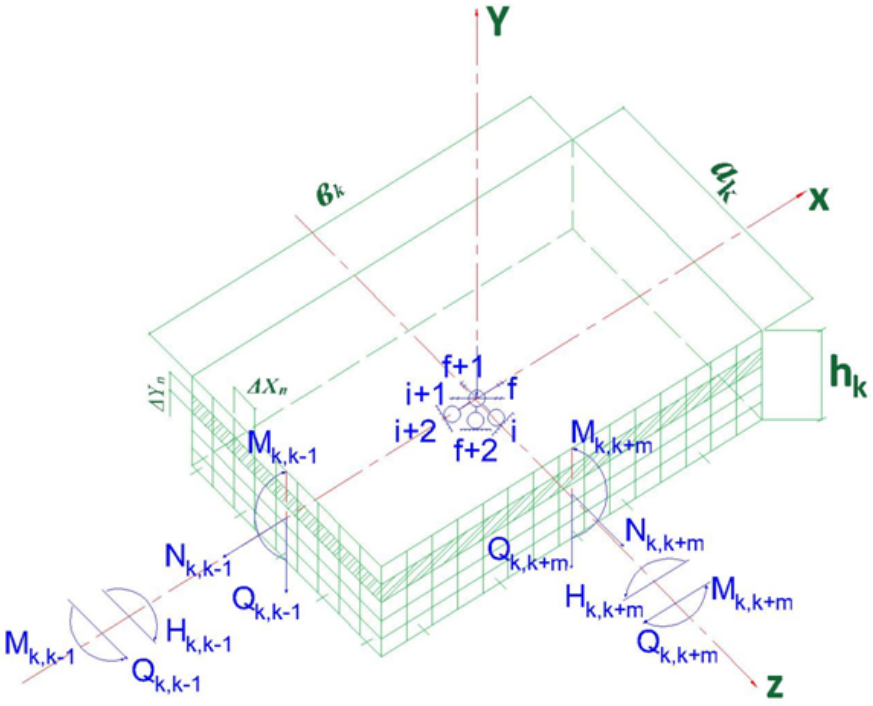

Рис. 2: Расчетная модель для сечения прямоугольной формы

Для участков между трещинами по гипотезе плоских сечений, используется среднее значение деформаций бетона и арматуры. Также допускается, подключение некоторого условно «растяжимого» бетона, который в целом сохраняет интегральные жесткостные свойства элементов. Тем не менее, вводимый в расчет «растяжимый» бетон, позволяет оценить ширину раскрытия трещин, как это сформулировано в работах [13].

Для расчета элементов аналогичное применение сделано недостаточно, что разъясняет максимальной физической схематичностью явления. Существенным ступенем в формировании расчетной методики с нелинейно-работающих элементов, возникшим употреблением вычислительной техники при использовании итерационных процессов. При расчете несущей способности и жесткости элементов и разрешило принимать всесторонние результаты, в наибольшем уровне сближающиеся с опытными данными.

В расчетах несущей способности, показанных в данной работе, сосредоточивало, что растянутый бетон действует с полной диаграммой деформирования «$\sigma_{вt}$ – $\varepsilon_{вt}$», овладевая нисходящую ветвь полной протяженности в локализации от выводных данных (рис. 3).

С точки зрения о «растяжимости» бетона, без увеличения его деформаций можно признать классическим изображение растянутого бетона в элементах, соответственно после появления в бетоне деформаций $\varepsilon = \varepsilon'_{вt}$ и напряжений $\sigma_{вt} = R_{вt}$ он исключает растяжение, в результате сечениях появляется трещина.

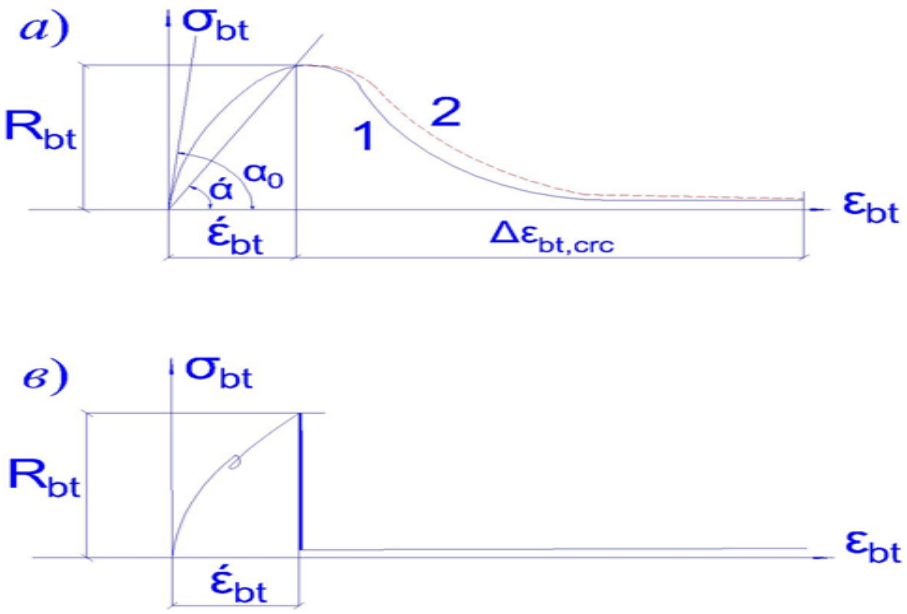

Рис. 3: Диаграммы деформирования «$\sigma_{вt}$–$\varepsilon_{вt}$» для растяжения бетона:
а) для первого случая бетона, б) для второго случая бетона

Исходя из вышеизложенного, следует перечислить некоторые недостатки:

- в расчетах должно проводиться рассмотрение напряженно деформированного состояния во всех сечениях и определить, имеются ли (или не имеются) трещины в бетоне;
- при расчетах высокой точности (итерации) может быть «зацикливание», т.е. с образованием трещин в растянутом бетоне создается изменение характеристики неустойчивости сечений.

Тем не менее, включение «растяжимого» бетона в расчетную методику, должно принимать соответствующее обоснование.

Представим, что с применением расчетной методики «растяжимого» бетона и использованием отдельных условий, можно получить равные результаты, имеющие место в расчетной методике с ограниченно растяжимым бетоном. При расчете элементов, следует учесть не только геометрическую нелинейность, но и физическую нелинейность.

При незначительном эксцентриситете нормальной силы N относительно главной оси деформация бетона на не более напряженной границе может быть совершенно небольшой и соответственно, секущий модуль деформации близок к первоначальному, т.е. $E'_m = E_m$.

Таким образом, физическая нелинейность, проходящей сквозь середину жесткостей элемента в условиях учета степени деформированного состояния, «отходит» от линии действия нормальной силы N, повышая первоначальный эксцентриситет.

В результате физической нелинейности, соответствующие максимально полученные величины деформированного состояния элемента «приближаются» к контуру действия нормальной силы N, при этом снизив первоначальный эксцентриситет.

По методу сосредоточенных деформаций физическая нелинейность на определенной ступени нагружения и в любом другом элементе принимается машинально, что в матрице жесткости сечения содержатся несколько элементов, в которых не равноправные нулю и размер тот или другой устанавливается величиной деформированного состояния в сечении.

Согласно [5 - 10], диаграммы «σ_m - ε_m» для бетона и арматуры при одноосном сжатии и растяжении принимаются в единообразной форме:

$$\sigma_m = E'_m \cdot \nu_m \cdot \varepsilon_m = E_m \cdot \varepsilon_m \quad (5)$$

где: ν_m – коэффициенты упругих деформаций материала (бетона, арматуры).

здесь: $E_m = \nu_m \cdot E'_m$; $\nu = e^{m\cdot(\varepsilon/\varepsilon)^{-m^{-1}}}$; $m = \ln(R_в / E_в \cdot \varepsilon)$.

В непластической стадии работы, если осевые координаты перемещены к основной, то физическая нелинейность приближаться к основной, в результате чего будет считаться главной.

Отсюда можно заметить, что в порядке произведений на показанные условия не принимается интерес, из этого принимаемые ответы могут включать погрешность, уровень которых устанавливается абстрактной расчетной ситуацией.

В частности расчет по деформированной схеме элементов останется тем же, что и для упругих элементов с различием, что на определенной итерации при образовании вектора дополнительных узловых моментов наряду с этим рассчитываются элементы матрицы жесткости и матрицы внешней жесткости.

Расчет железобетонных элементов на основе изложенного осуществляется по программе и алгоритму на компьютерной технологии.

При этом решались следующие задачи:

- установление параметров, т.е. точности ω при минимальном числе итераций;
- нахождение рациональных приемов разбивки сечений на элементарные участки;
- проверка требуемых схем о разбивке железобетонных элементов на элементы метода сосредоточенных деформаций;
- проверка подсчета деформаций и перемещений для железобетонных элементов в упругой работе, с учетом деформирования расчета при разных условиях опирания и нагружения.

Указанные задачи решались по данным различных опытов, которые присущи расчетным условиям.

III. РЕЗУЛЬТАТЫ

Пример 1: Рассмотрим прямоугольное сечение с одиночной арматурой в условиях прямого изгиба (рис. 4).

Требуется определить несущую способность нормальных сечений по методу сосредоточенных деформаций и сопоставить с результатами опыта.

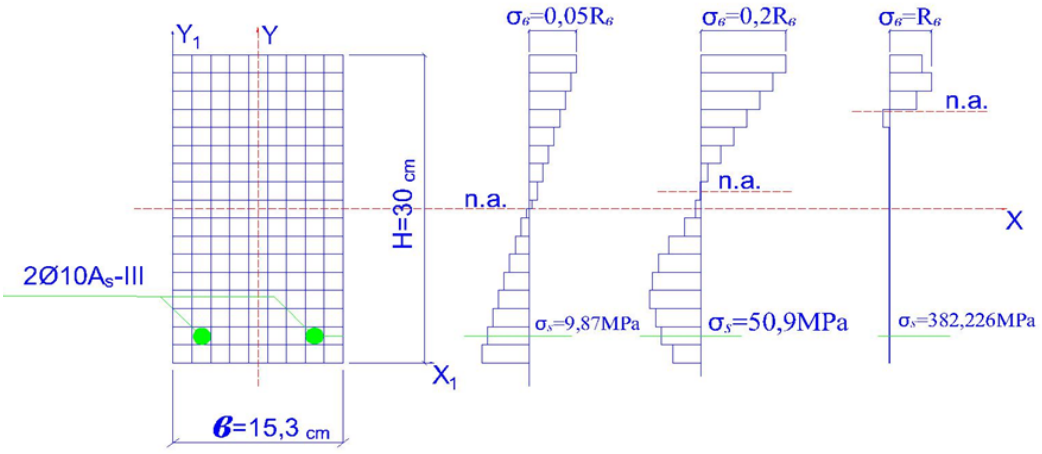

Рис. 4; Изгибаемый элемент с одиночной арматурой

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Отыскивание вектора, соответствующего несущей способности, т.е. сформированного поэтапного повышения вектора {F} (ступени приняты $0{,}1\cdot\{F\}^*_{опыт}$), при котором появлялись разрушения, т.е. доходил вектор $\{F\}_{max}$. Затем вектор $\{F\}^*$ применялся между $\{F\}^* - 0{,}1\cdot\{F\}^*_{опыт}$ и $\{F\}^*$ с точностью $\Omega = 0{,}01$.

Ступени нагружения вектора $\{F\}^*$ определяются исходя из приближенного расчета, при этом должно осуществляется, по вероятности, полагая, что точность итерационного расчета $\Omega = 0{,}01$ в оценочном расчете вектора $\{F\}^*$ мало трансформирует искомый результат.

Отсюда следует, что при небольших степенях нагружения итерационные процессы с точностью $\omega = 0{,}01$ сближаются быстро, на первых ступенях за 5-7 итераций, а для достижения точности на конечных ступенях потребуется несколько десятков итераций. Разрушение, выявленное по материалам расчетов, соответственно предполагать разрушение бетона: в растянутой арматуре напряжение одолело предел текучести, но не достигло временного сопротивления ($\sigma_{s,расч.}$ = 382,226 МПа), при этом деформация составила 2,2%.

Таким образом, следует утверждать, что принятое расчетом напряженно -деформированное состояние элемента соответствует этапу разрушения, а результаты разрушающего момента ближе к опытному, т.е. меньше опытного на 8,8%.

Пример 2: Произвести расчет несущей способности и жесткость железобетонных элементов прямоугольного сечения (В·Н =15,3х30,5 см, длиной 3м) и загруженной сосредоточенными силами в 2-х точках. Характеристики материалов: бетон - $R_в$ = 29,5 МПа, $R_{вt}$ = 1,6 МПа, $E_в$ = 39500 МПа; $\underline{\underline{\varepsilon}}_в$ = 2,5 %; арматура - 2Ø16 класса А-II с R_y= 359 МПа, R_{su} = 498 МПа, E_s= $2\cdot10^5$ МПа.

Расчет осуществлялся на компьютерной технологии (рис. 5).

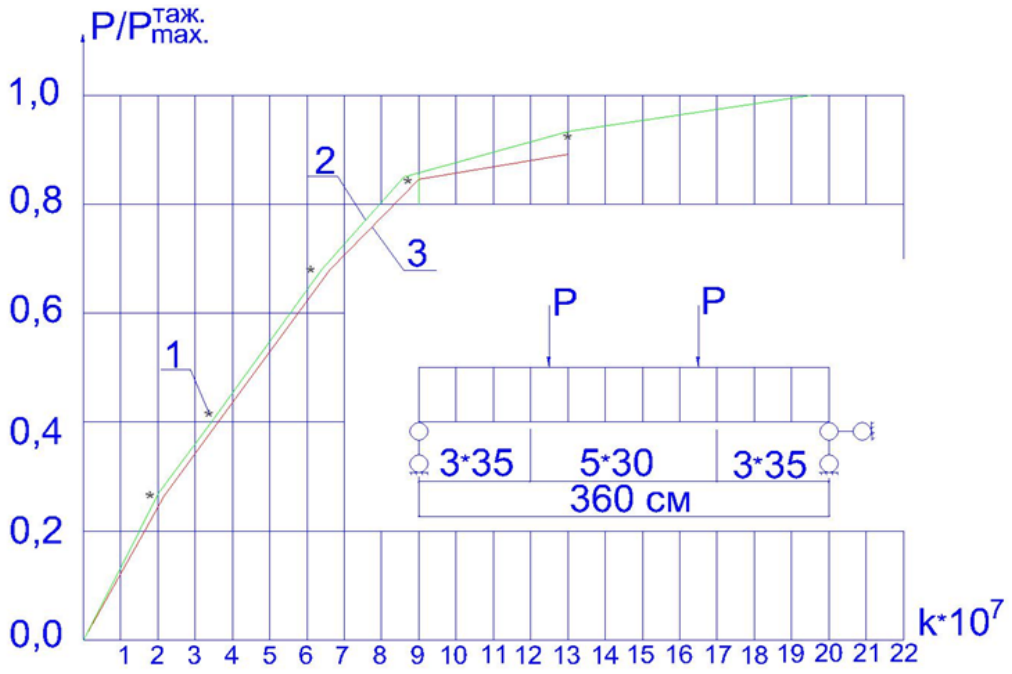

Рис. 5: Изменение кривизны продольной оси при загружении: 1 – по СниП, 2 – по методу сосредоточенных деформаций, 3 – по опыту

Железобетонный элемент в пролете разбит на 11 элементов методом сосредоточенных деформаций с тремя степенями свободы, длиной 0,35 м и 0,3 м. Разрушающая нагрузка по расчету составила P^{*} = 33 кН, экспериментальное значение $P^{*}_{экс.}$ = 33,3 кН.

В упругой стадии работы прогибы элемента в середине пролета различаются от аналитически вычисленных на +0,547%, углы поворота в опорных элементах на +0,8%, кривизны в середине пролета – на 0,01%.

Таким образом, что вычисления прогиба по изложенной методике при сравнительно небольшом числе элементов метода сосредоточенных деформаций дают значительную точность.

На рис. 6, представлены эпюры кривизны и изгибающих моментов для двух ступеней загружения при нагрузке, составляющей 70% от разрушающей и 96% от разрушающей.

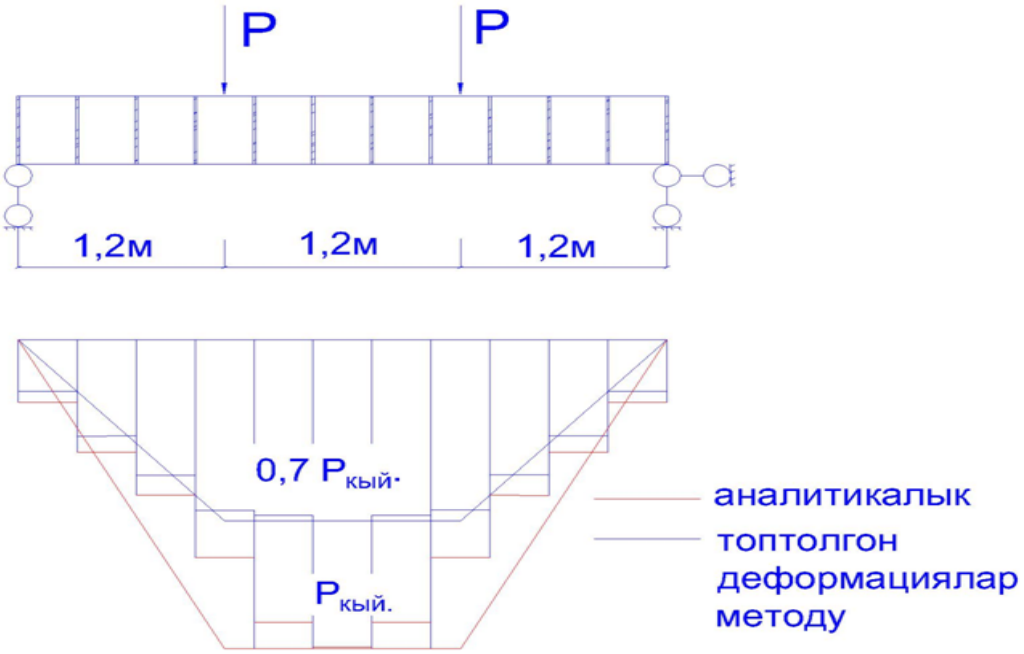

Рис. 6: Эпюры изгибаемых моментов

Отсюда следует, что с увеличением нагрузки эпюра кривизны постепенно отклоняется от эпюры изгибающих моментов. При нагрузке 70% от разрушающей составила +1,3% и при нагрузке в 96% от разрушающей нагрузки +17% по сравнению с расчетами по методу сосредоточенных деформаций.

IV. ВЫВОДЫ

1. В расчетах приводятся полные диаграммы деформирования «σ – ε» для бетона и арматуры с учетом нисходящей ветви, при различных условиях нагружения.
2. Расчетные положения, в данном исследовании, основываются на характеристики жесткости, вычисляемых сравнительно, произвольно принятых координатных осей.
3. По разработанному алгоритму решается задача проверки несущей способности статистически неопределимого элемента при заданных нагрузках и принятых размерах сечений, классах бетона и арматуры, а также длительности действия внешней нагрузки.

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Comprehensive Rehabilitation of Patients with Pneumonia Caused by COVID-19 at the Ambulatory Stage

T.A. Novikova, E.A. Popov, T.V. Rubanik, N.V. Shapiro, N.L. Shaporova & A.V. Tishkov

ABSTRACT

Lung damage caused by the SARS-COV-2 virus is a serious obstacle to recovery in patients with COVID-19-associated pneumonia. The treatment of post-COVID-19 syndrome is currently a significant problem in world health care.

Therefore, pulmonary rehabilitation is important at all stages of the disease. The article presents programs of restorative treatment, such as physiotherapy, haloinhalation, exercise therapy and hyperbaric oxygenation. Their influence on the indicators of the function of external respiration, on blood tests, CT, pulse oximetry, and on the assessment of dyspnea according to the mMRS questionnaire was considered. It is known that with coronavirus infection, diffuse alveolar damage develops, which can lead to a violation of the diffusion capacity of the lungs (DSL). The article discusses the effect of hyperbaric oxygenation on DSL indicators.

Keywords: COVID-19; post-COVID-19 syndrome; pulmonary rehabilitation; hyperbaric oxygena- tion; lung diffusion capacity.

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Comprehensive Rehabilitation of Patients with Pneumonia Caused by COVID-19 at the Ambulatory Stage

Комплексная реабилитация пациентов, перенесших коронавирусную пневмонию, на амбулаторном этапе

T.A. Novikova[α], E.A. Popov[σ], T.V. Rubanik[ρ], N.V. Shapiro[Ↄ], N.L. Shaporova[¥] & A.V. Tishkov[§]

АННОТАЦИЯ

Повреждение легких, вызванное жизнедеятельностью вируса SARS-COV-2, является серьезным препятствием к выздоровлению пациентов с COVID-19- ассоциированной пневмонией. Лечение постковидного синдрома в настоящее время- значимая проблема мирового здравоохранения.

Именно поэтому проведение пульмонологиче-ской реабилитации важно на всех этапах болезни. В статье представлены программы комплексной реабилитации, включающие физиолечение, галоингаляции, лечебную физкультуру и гипербарическую оксигенацию. Изучено влияние данных методов на показатели функции внешнего дыхания, анализы крови, состояние органов грудной клетки по результатам компьютерной томографии, пульсоксиметрии, одышки по опроснику mMRS. Известно, что при коронавирусной инфекции развивается диффузное альвеолярное повреждение, которое может привести к нарушению диффузионной способности легких. В статье рассматривается влияние гипербарической оксигена- ции на показатели диффузионной способности легких.

Ключевые слова: COVID-19; постковидный синдром; пульмонологическая реабилитация; гипербарическая оксиге- нация; диффуз-ионная способность легких.

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I. ВВЕДЕНИЕ

В настоящее время борьба с новой коронавирус- ной инфекцией (COVID-19) стала приоритетной задачей мирового здравоохранения. Известно, что после выздоровления и выписки из стационара у пациентов в течение продолжительного времени сохраняются одышка, утомляемость, снижение работоспособности, потеря памяти и другие симптомы.

Так появился новый термин - постковидный синдром (*син.:* long COVID; post-COVID-19 syndrome; post-acute COVID-19 syndrome), описывающий признаки и симптомы, которые развиваются в течение заболевания COVID-19 или после него, продолжающиеся более 12 нед, возникающие волнообразно или на постоянной основе и не имеющие альтернативного диагноза (консенсусное определение пока от- сутствует).

Постковидный синдром получил официальный статус болезни и появился в новой редакции Международной классификации болезней 10-го пересмотра под кодом U09.9 Post-COVID-19 condition. В основе патогенеза постковидного синдрома лежат следующие механизмы: нейротропность и нейровирулентность, патологический иммунный ответ, по- вышенное тромбообразование [1].

Известно, что при коронавирусной инфекции развивается диффузное альвеолярное повреждение, сопровождаемое альвеолярно-геморрагическим синдромом и распространенным тромбозом микроцир- кулято-рного русла, что служит причиной гипоксии и дыхательной недостаточности [2]. В связи с этим можно предположить, что наиболее значимым функциональным нарушением респираторной системы при COVID-19 является нарушение диффузионной способности легких (ДСЛ), которое также может сохраняться при постковидном синдроме.

Данное предположение подтверждается результатами отечественных и зарубежных исследований. Так, по данным X. Мо и соавт. [3], нарушение диффузионной способности легких в ранний период выздоровления пациентов, перенесших COVID-19, было выявлено в половине случаев. В исследованиях сотрудников Главного военного клинического госпита-ля имени академика Н. Н. Бурденко [4] было показано, что в ранний период выздоровления после COVID-19 более чем у половины пациентов отмечалось наруше- ние ДСЛ [5, 6]. J.

Frija-Masson и соавт. [7] выявили респираторные нарушения у 54% пациентов на 30-й день после появления первых симптомов COVID-19.

Функциональные нарушения респираторной си- стемы после COVID-19 (нарушение ДСЛ) влияют на качество жизни пациентов, служат причиной одышки, слабости и утомляемости [8], что обуслов- ливает особенности пульмонологической реабилитации этих пациентов на всех этапах болезни и диктует необходимость поиска новых подходов к ведению больных с постковидным синдромом.

Список сокращений

ГБО — гипербарическая оксигенация
ДСЛ — диффузионная способность легких

В отечественной и зарубежной литературе активно обсуждаются вопросы легочной реабилитации после COVID-19. Согласно

Временным методическим рекомендациям по медицинской реабилитации пациентов с новой коронавирусной инфекцией COVID-19 от Союза реабилитологов России [9], медицинская реабилитация включает три этапа.

Первый — оказание медицинской помощи по медицинской реабилитации в отделениях интенсивной терапии и инфекционно-терапевтических отделениях, организованных для пациентов с новой коронавирусной инфекцией. Второй этап проводится в отделениях медицинской реабилитации пациентов с соматическими заболеваниями, третий в амбулаторно-поликлинических и санаторно-курортных (при наличии реабилитационного отделения) медицинских учреждениях. Реабилитационные мероприятия позволяют значимо восстановить дыхательную функцию у пациентов, улучшить качество жизни, сократить сроки времен- ной нетрудоспособности и уменьшить число случаев первичной инвалидности [10].

II. СХЕМА МАРШРУТИЗАЦИИ ПАЦИЕНТОВ

СПб ГБУЗ «ГКДЦ № 1» является крупнейшим лечебно - профилактическим амбулаторным учреждением Санкт-Петербурга, где проводится обследование и лечение больных различных профилей. С июня 2020 г.

учреждение одним из первых в городе организовало реабилитационное лечение пациентов, перенесших коронавирусную пневмонию. За год (с июня 2020 по июнь 2021 г.) пульмонологическая реабилитация была проведена более чем 1000 пациентам. Обследование и ведение этих больных проводилось по следующему алгоритму (рис. 1).

Одним из звеньев в патогенезе COVID-19 является развитие гипоксии. Формирование данного патологического процесса происходит по нескольким механизмам: нарушение диффузии кислорода через альвеолярно-капиллярную мембрану в результате воспалительного процесса в легочной ткани; нарушение кислородно-транспортной функции гемоглобина, обусловленное токсическим воздействием белка вируса; образование микротромбов-

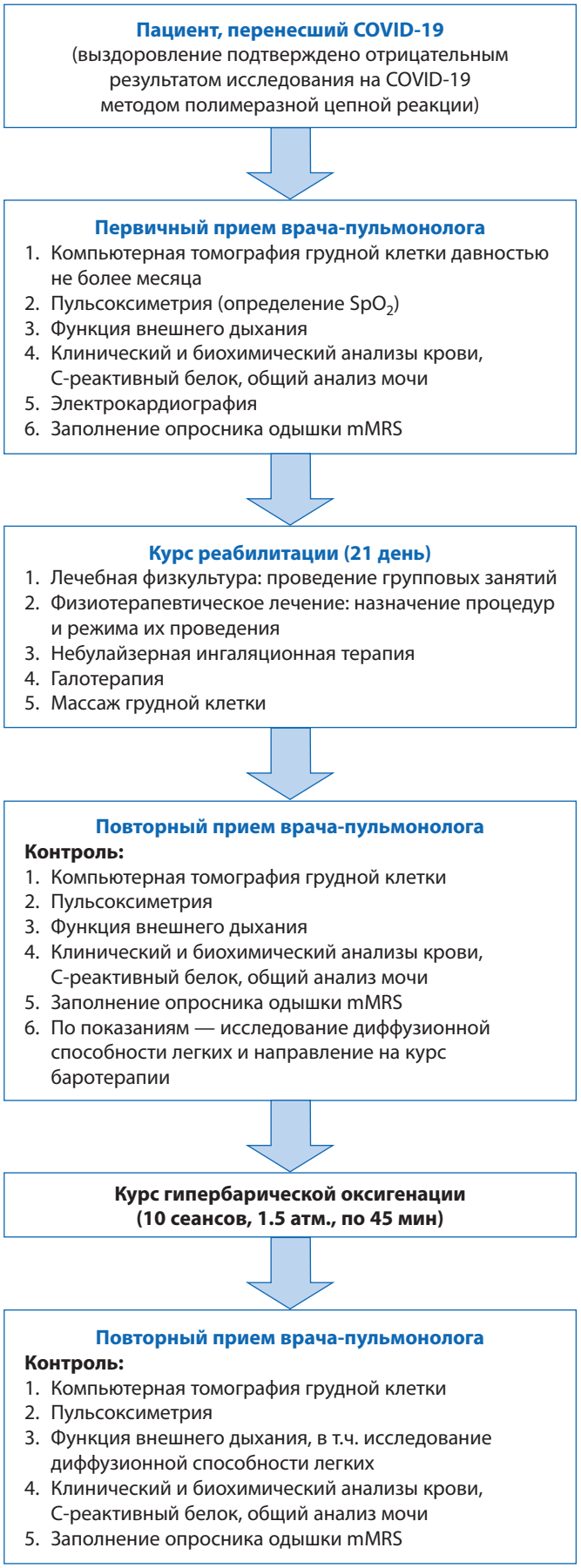

Рис. 1: Схема маршрута пациента на 3-м этапе реабилитации после COVID-19 (амбулаторная помощь)

в капиллярах, связанное с нарушением микроциркуляции [11]. Исследования показали высокую эффективность и безопасность лечения гипоксии методом гипербарической оксигенации (ГБО) в терапевтиче- ском режиме (1,3–1,6 АТА 30–45 мин). ГБО успешно применялся у больных с нагноительной патологией легких [12–14], в комплексном лечении больных ту- беркулезом [11] и хроническими обструктивными заболеваниями лёгких [14]. У больных наблюдались улучшение общего самочувствия, нормализа- ция сна, уменьшение одышки, повышение переносимости физической нагрузки, что способствовало улучшению качества их жизни и социальной адап- тации [14]. И. В. Безенков [15] и П. Н. Савилов [16] объясняют это биологическим эффектом гипероксии, в основе которого лежит формир- ование новых функциональных систем, повышающих саногенный потенциал организма в условиях сверхнасыщения организма кислородом [17]. П. Н. Савилов счита- ет возможным включать ГБО в терапию больных COVID-19-ассоциированной пневмо- нией не только как средство устранения гипоксемии, но и как адаптогенный регулятор метаболических процессов, протекающих в больном организме [11]. Лечение методом гипербарической оксигенации способствует уменьшению воспалительных процессов, увеличивает парциальное давление кислорода в плазме крови и восстанавливает кислородный баланс в тканях организма, уменьшает образование пневмофиброза [18–20]. Баротерапия повышает переноси- мость физических нагрузок и интенсивность тренировок.

С учетом вышеизложенного, задачей настоящего исследования было проанализ- ировать эффективность предложенного алгоритма реабилитации пациентов с постковидным синдромом и целесооб- разность дополнительного включения ГБО в комплексный план реабилитации этих больных.

III. ЭФФЕКТИВНОСТЬ АЛГОРИТМА РЕАБИЛИТАЦИИ

Для решения указанной задачи нами был проведен анализ результатов пульмоно- логической реабилитации 98 пациентов, обследование и лечение которых соответст- вовало приведенной выше блок-схеме. Сред- ний возраст пациентов составил 56,9 (11,3) лет. Об- следовано 45 (45,9%) мужчин и 53 (54,1%) женщины.

Всем пациентам оценивали клинический статус и выраженность одышки, выполняли пульсоксиме-трию (показатели колебались в пределах нормаль-ных значений — от 95 до 98%), определяли уровень СРБ в анализе крови (среднее значение 7,5), измеряли функцию внешнего дыхания (исходно и в пробе с бронхолитиком), выполняли электро- кардиографию и компьютерную томографию (КТ) груднойклетки. Курс пульмоно- логической реабилитации проводился в течение 21 дня и включал следующие процедуры: занятия лечебной физкультурой (еже- дневно по 45 мин), физиоте- рапевтические процедуры (сверхвысоко- частотное электромагнитное поле, низкоча- стотную магнитотерапию, высокочастотную импульсную магнитотерапию, электрофорез лекарственных препаратов, СМТтерапию (синусоидально модулированный ток), массаж грудной клетки), ингаляционную терапию (небулайзерное введение лекарственных средств, галоингаляции).

Все исследования выполнялись в динамике до начала и по завершении указанного алгоритма пульмо- нологической реабилитации.

Дополнительно десятидневный курс ГБО получили 40 пациентов из анализируемой нами группы (n=98) с сохранявшимися проявлениями постко- видного синдрома.

Продолжительность процедуры составила 45 мин; давление, создаваемое в камере, — 1,5–1,7 АТА. Группу сравнения составили 58 пациентов, которым дополнительный курс ГБО не проводился. Дополнительно дифф- узионную способность легких до и через месяц

по заверше- нии курса реабилитации определяли 28 пациентам (из них 14, получившим курс лечения ГБО, и 14 из группы сравнения).

Описательная статистика для количественных данных приводилась в виде среднего и стандартно- го отклонения M (SD), для качественных — в виде количества и доли (процентов) вхождения данного значения в выборку. Проверка гипотез о различиях между выборками проводилась при помощи парного и непарного критерия Стьюдента.

Выборочные распределения для количественных показателей были согласованы с нормальным распределением, проверка проводилась при помощи критерия Колмогорова–Смирнова. Для качественных показателей проверка гипотез осуществлялась при помощи кри- терия хи-квадрат.

Критический уровень значимости при проверке гипотез принимали равным 0,05.

Проведенные исследования показали, что половина пациентов предъявляли жалобы на кашель: в 32 (65,3%) случаях — сухой, в 17 (34,7)% — с от- делением мокроты. Среди больных, принятых на ре- абилитационное лечение, 86,7% отмечали одышку при небольшой физической нагрузке, и связанную с ней низкую толерантность к физическим нагруз- кам, слабость и быструю утомляемость.

Больные с одышкой при заполнении модифицированного опросника mMRS (оценка тяжести одышки) значи-мо отличались от пациентов без одышки (p <0,001).

В табл. 1 обращает внимание, что одышка (и, соответственно, более высокое значение mMRS) чаще беспокоила лиц старшей возрастной группы (p <0,001) и больных с большим объемом поражения легких по КТ (p <0,001). Среднее значение mMRS у всей группы пациентов до начала лечения составило 2,7 балла.

Дополнительный анализ распространенности поражения легочной ткани у больных с постковидным синдромом, включенных в настоящее исследование, показал, что более половины перенесли среднетяжелое течение пневмонии с поражением легочной ткани по КТ от 25 до 50% (КТ-2). У 1/4 пациентов заболевание протекало тяжело с большим объемом поражения (КТ-3), и лишь у 8% больных имело место легкое течение заболевания (КТ-1); табл. 2.

По завершении курса реабилитации была отмечена субъективная и объективная положительная динамика: у половины пациентов исчез или значи- тельно уменьшился кашель, более чем у 1/3 больных исчезла одышка, а средний индекс одышки уменьшился в 1,4 раза (с 2,67 до 1,92 балла); рис. 2.

Половине пациентов после курса реабилитации была выполнена контрольная КТ легких. Это были больные с объемом поражения легочной ткани более 50% (среднее значение 56,3±5,4%). У всех больных имела место положительная рентгенологическая динамика, уменьшились объем и интенси- вность легочного поражения (p <0,001). Отмечалось также повышение абсолютных значений функциональ-

Таблица 1: Выраженность одышки (исходные значения)

Показ атель	*n* (%)	Средний возраст, лет	Компьютерная томография (поражение легких, средние значения в группе, %)
Одышка присутствовала	85 (87)	59,0±10,1	45,8±10,1
Опросник MMRS (среднее значение)	2,86		
Одышка отсутствовала	13 (13)	43,0±8,6	27,9±7,1
Опросник MMRS (среднее значение)	1,46		
ВСЕГО	98	56,9±11,3	43,4±11,5
Опросник MMRS (среднее значение всей группы)	2,7		

Таблица 2: Поражение легочной ткани (исходные значения)

Поражение легочной ткани, %	Среднее значение, %	Число пациентов, *n*
КТ-1 (20–25)	22	8
КТ-2 (26–50)	40,3	64
КТ-3 (51–75)	57,7	26
Всего	43,4	98

ных показателей внешнего дыхания ($ОФВ_1$ и ФЖЕЛ в среднем на 10%), улучшение процессов реполяризации на электрокардиограмме, снижение концентрации С-реактивного белка в 1,2 раза (рис. 3).

Однако у 40 пациентов по завершении трехнедельного курса реабилитации сохранялись слабость, одышка, низкая толерантность к физической нагрузке и распространенные изменения легких по КТ. Для

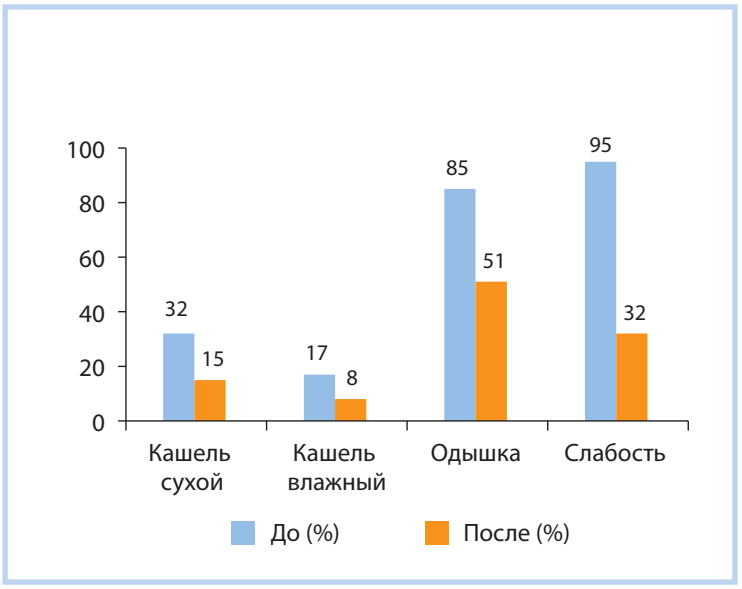

Рис. 2: Динамика жалоб пациентов до и после реабилитации

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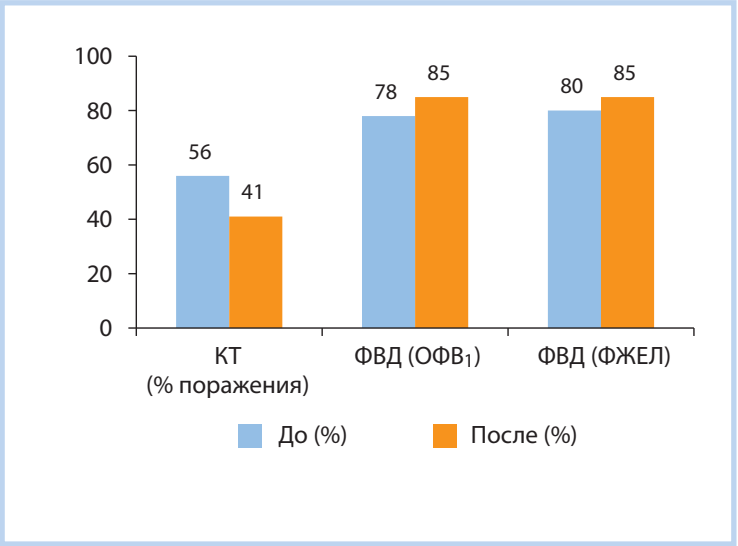

Рис. 3: Динамика результатов обследования пациентов до и после реабилитации

дальнейшего лечения эти пациенты были направлены в центр оксигенобаротерапии СПб ГБУЗ «ГКДЦ № 1», где им был проведен десятидневный курс ГБО. Продолжительность процедуры составляла 45 мин; давление, создаваемое в камере, — 1,5–1,7 АТА.

По завершении курса баротерапии все пациенты отмечали существенное уменьшение слабости (p <0,001) и одышки (p <0,001), лучшую переносимость физических нагрузок. Практически у всех больных исчез кашель (p <0,010); рис. 4.

Показательна динамика изменений шкалы одышки mMRS (табл. 3). Если вначале реабилитационного лечения одышка разной степени выраженности (от легкой при быстрой ходьбе или подъеме на небольшое возвышение до тяжелой, заставляющей больного делать остановки через несколько минут ходьбы по ров-

Таблица 3: Динамика шкалы одышки mMRS

Исходное значение (n=98)	2,7	
↓		
После реабилитации (n=98)	2,35	
↓	↓	
1,15	1,60	
После ГБО (n=40)	Без ГБО (n=58)	

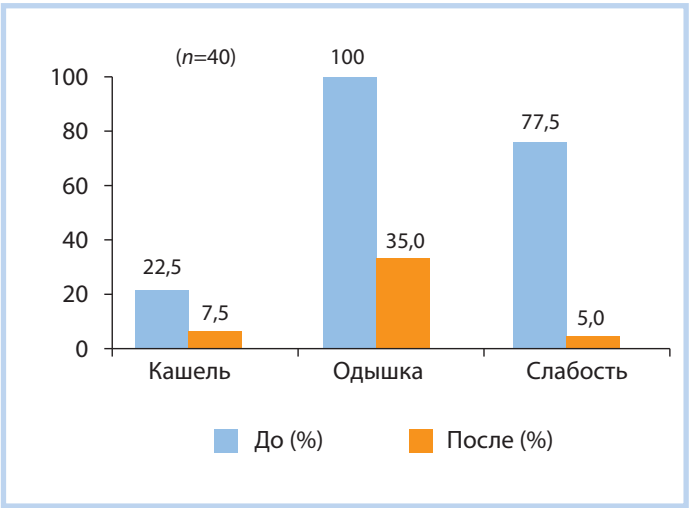

Рис. 4: Динамика жалоб пациентов до и после курса гипербарической оксигенации

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ной местности) беспокоила всех пациентов, и сред- ний показатель mMRS составлял 2,7 балла, то после курса реабилитации он снизился на 13% — 2,35 балла (p <0,001). В группе пациентов, получивших лечение в барокамере, индекс одышки снизился еще вдвое (p <0,001), а у 9 из них одышка исчезла полностью. У больных группы сравнения одышка также стала ме- нее выраженной, но в меньшей степени.

Через месяц после завершения курса пульмоно- логической реабилитации всем пациентам была вы- полнена контрольная КТ легких (табл. 4).

Данные табл. 4 свидетельствуют, что в целом распро- страненность поражения легочной ткани через 2 мес лечения уменьшилась почти вдвое (с 43,4 до 24,3%), p <0,001. Однако пациенты, получившие 10-дневный курс лечения в барокамере, изначально имели более тяжелое течение заболевания и больший объем по- ражения легочной ткани по КТ (54,4%), чем боль- ные группы сравнения (35,9%); p <0,001. Улучшение рентгенологической картины по КТ у пациентов, по- лучивших последовательно курсы пульмонологической реабилитации и гипербарической оксигенации, было более значимым, чем за то же время у больных, получивших только реабилитацию, — на 30,0±6,3 и 11,7±7,5% соответственно, p <0,001.

Анализ КТ в группе пациентов, получивших по- следовательно оба метода лечения, свидетельству- ет об уменьшении распространенности изменений в легочной ткани после пульмонологической реабилитации на 15,2±6,1% (p <0,001) и на 11,9±8,7% (p <0,001) после последующей баротерапии, оба из- менения статистически значимы (p <0,001).

Анализ ДСЛ, выполненный в динамике (до и че- рез месяц после курса реабилитации) 28 пациентам после коронавирусной пневмонии (14 получили ле- чение в барокамере и 14 из группы сравнения), пред- ставлен в табл. 5.

Таким образом, у пациентов, прошедших ГБО, диффузионная способность легких увеличилась на 16,2%, когда как в группе сравнения наблюдалось небольшое снижение ДСЛ (на 0,76%).

Пациенты отмечали существенное уменьшение ощущений слабости и одышки, значительно лучшую переносимость физических нагрузок.

Нежелательных явлений и серьезных нежелатель- ных явлений при проведении ГБО нами не зареги- стрировано.

IV. ЗАКЛЮЧЕНИЕ

Проведение реабилитации, включающей в себя ды- хательные упражнения, ингаляционную небулайзер- ную, физио- и галотерапию, у пациентов, перенесших COVID-пневмонию, уменьшает проявления и степень выраженности остаточных изменений заболевания.

Проведение баротерапии на этапе реабилитации у этих пациентов эффективно для уменьшения выраженности одышки, улучшения переносимости физических нагрузок и других проявлений постко- видного синдрома, способствует более быстрому разрешению интерстициальных изменений в легких.

Таблица 4: Динамика изменений по результатам компьютерной томографии после курса реабилитации с использованием гипербарической оксигенации

Пациенты	Исходные данные	После реабилитации (через 1 мес)	Через 2 мес
	Поражение легких, средние значения, %		
Всего (n=98)	43,4±11,5	-	24,3±7,4
Получили ГБО (n=40)	54,4±6,1	41,0±6,1	24,4±7,0
Без ГБО (n=58)	35,9±7,6	Не выполнялась	24,2±7,8

Примечание. ГБО — гипербарическая оксигенация

Таблица 5: Динамика изменений диффузионной способности легких в группах гипербарической оксигенации и сравнения

Группа	Число пациентов, n	До, %	После, %
		DLCO, мл/мин/мм рт.ст.	
Получили курс ГБО	14	84	97,6
Группа сравнения	14	78,8	78,2

Примечание. ГБО — гипербарическая оксигенация; DLCO (Diffusing Capacity Of The Lungs For Carbon Monoxide) — метод исследования функции легких, позволяющий количественно оценить процесс диффузии газов через альвеолярно-капиллярная мембрану, или эффективность транспорта кислорода из альвеол в кровоток.

Совместное последовательное использование дан- ных методов реабилитации имеет дополнительное положительное влияние на респираторную систему пациентов, перенесших COVID-19, и может быть рекомендовано к применению в рутинной практике на 3-м амбулаторном этапе реабилитации.

Дополнительная информация Источник финансирования

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Competing interests

The authors declare that they have no competing interests.

Вклад авторов

Т. В. Рубаник — написание текста статьи; Т. А. Новикова — набор материала, поисково-ана- литическая работа; Н. В. Шапиро — набор мате- риала; Е. А. Попов, Н. Л. Шапорова — обсуждение и редактирование текста статьи; А. В. Тишков — ма- тематическая обработка данных. Все авторы подт- верждают соответствие своего авторства между- народным критериям ICMJE (все авторы внесли существенный вклад в разработку концепции, про- ведение исследования и подготовку статьи, прочли и одобрили финальную версию перед публикацией).

Author contribution

T. V. Rubanik — writing the text of the article; T. A. Novikova — set of material, search and

analytical work; N. V. Shapiro — a set of material; E. A. Popov.

N. L. Shaporova — discussion and editing of the text of the article; A. V. Tishkov — mathematical data processing. All authors confirm the compliance of their authorship with the international ICMJE criteria (all authors made a significant contribution to the development of the concept, research and preparation of the article, read and approved the final version before publication).

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Dermoscopic Skin Cancer Image Segmentation and Classification using Machine Learning Technique

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ABSTRACT

More and more chromosomal and metabolic abnormalities are now known to cause cancer, which is typically fatal. Anybody component may become infected by tumor cells, which can be fatal. One of the most prevalent types of cancer is skin cancer, and its prevalence is rising around the globe. Early diagnosis and delineation of the lesion margins are crucial for precise malignant region identification and clinical treatment of skin lesions. Skin cancer incidence is greater than average, particularly melanoma, which is more dangerous because of its high rate of metastasis.

Therefore, early detection is essential for treating it before malignancy develops. The analysis and segmentation of lesion boundaries from dermoscopic images is done in order to solve this issue. A variety of techniques have been utilised, from textural assessment of the photographs to visual assessment of the images.

Keywords: skin cancer, convolutional neural network, deep learning, dermoscopic image, ISIC2018 dataset.

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ABSTRACT

More and more chromosomal and metabolic abnormalities are now known to cause cancer, which is typically fatal. Anybody component may become infected by tumor cells, which can be fatal. One of the most prevalent types of cancer is skin cancer, and its prevalence is rising around the globe. Early diagnosis and delineation of the lesion margins are crucial for precise malignant region identification and clinical treatment of skin lesions. Skin cancer incidence is greater than average, particularly melanoma, which is more dangerous because of its high rate of metastasis.

Therefore, early detection is essential for treating it before malignancy develops. The analysis and segmentation of lesion boundaries from dermoscopic images is done in order to solve this issue. A variety of techniques have been utilised, from textural assessment of the photographs to visual assessment of the images.

However, due to the sensitivity involved in surgical interventions or drug distribution, the accuracy of these techniques is poor for real clinical therapy. This offers a chance to create an automatic system that is accurate enough to be applied in a clinical environment. Epithelial tissue and basal cell carcinomas, as well as melanoma, which is medically severe and causes the majority of deaths, are the main subtypes of skin cancer.

Monitoring for skin cancer is therefore essential. Machine learning is one of the greatest ways to quickly and precisely identify skin cancer. To use the ISIC2018 database, the convolution neural network (CNN) deep learning technique was employed in this study to identify the two main categories of tumors, malignant and benign.

Skin lesions, comprising benign and malignant tumors, are included in this database. The images were initially enhanced and edited using ESRGAN. The pre- processing stage involved resizing, normalizing, and augmenting the images. Using a CNN approach, skin lesion images might be categorized based on an accumulation of data collected after numerous repetitions. The experimental results show that the proposed methodology performance is better than existing methodologies.

Keywords: skin cancer, convolutional neural network, deep learning, dermoscopic image, ISIC2018 dataset.

I. INTRODUCTION

Tumor is the unregulated growth of tissues in a particular body part. It appears that skin cancer is one of the global diseases that spreads the fastest.

Skin cancer is a condition in which uncontrolled development of abnormal skin cells occurs. Early identification and precise diagnosis are crucial for determining viable cancer therapy. The most common cause of skin cancer-related mortality in industrialized nations is melanoma, the deadly type of skin cancer. Squamous cell carcinoma, squamous cell, Merkel cell cancer, dermato-fibroma, microvascular, and benign pathology are the main kinds of melanoma [1].

Skin cancer is among the most lethal forms of cancer worldwide, and it is causing an increasing

number of fatalities every day. It is also one of the cancer forms that spreads the fastest. However, if it is discovered in its early stages, therapy is doable [2]. Recent figures show that 20% of skin cancer cases progressed to the point where survival is impossible as a result of the illness.

Skin cancer is responsible for 50,000 deaths worldwide annually, or 0.7 of all cancer-related fatalities. Around USD 30 million is the anticipated cost of the procedure, which is prohibitive. Early skin cancer detection is essential to ensuring a benign course and lower mortality rates, however reliable cancer detection frequently relies on screening mammography with insufficient sensitivity, which is subsequently confirmed by clinical samples [3].

The use of this method for cancer detection and treatment response assessments is typically inappropriate. Artificial intelligence (AI) for diagnostic purposes is being used by a growing number of healthcare professionals to enhance and speed up the medical decision-making process [4]. However, the accurate analysis and adequate presentation of projected defects have been completely or mostly overlooked by presently offered AI research for clinical diagnosis, despite some recent signs of advancement in this arena. The scientific community has given computer-aided technology for the diagnostics interpretation of medical pictures a lot of attention [5]. These are effectively created and altered for the objectives of, among others, classifying and segmenting the area of interest (AOI), which in this case includes malignant spots. It goes without saying that early diagnosis and delineation of lesion borders are essential for the successful chemotherapy of cancer, particularly in the initial stages while the disease is still developing [6]. Each year, 9.6 million people die from cancer related causes and almost 17 million individuals are impacted by the disease. As a result, cancer is now the top cause of mortality globally. In the instance of skin cancer, it arises or develops in the epidermal cells and is one of the most common kinds of the illness in both children and adults. For the purpose of detecting cancer boundaries from dermoscopic pictures, many computer-aided methods have been created [7]. Due to its high probability of metastasis, carcinoma is not only the most common and lethal kind of skin cancer, it is also highly severe and destructive. The aggressive skin cancer known as melanoma arises from the uneven proliferation of melanocytes, which are colored skin cells. It can appear anywhere on the skin's epithelial tissue and is perhaps able to spread from the initial location of the malignancy to the chest and back. It has the highest fatality rate of any kind of skin cancer and its prevalence rate has increased by up to 4-6% yearly. Timely diagnosis is crucial since it raises the chance of survival for five years by up to 98%.

Given the information provided above on the prevalence and death rate of melanoma, early detection is even more important for those who are afflicted to receive appropriate care. There are two streams of techniques for the identification and fragmentation of lesion boundaries [8]: first, common methods that typically rely on the clinician's visual inspection; and second, semi-automated and done by machines methods that primarily use argument intensity values operations, pixel cluster - based techniques, level set strategies, deformable modeling techniques, deep-learning based techniques, etc.However, due to the inherent limits of the approaches and the shifting characteristics of dermoscopic pictures brought on by fluorescence emission and luminance in homogeneities, the majority of the techniques applied today are not moderately.

Because of this, more advanced techniques have become popular, like convolutional neural networks (CNNs). In this study, we aim to use CNN-based model topologies and attributes to the delimitation and segmentation of skin lesion boundaries. Additionally, we add our original innovation—image inpainting—to the already existing approaches that significantly improves segmentation results. Image inpainting is utilised to eliminate the hair complex working environment in the dermoscopic images that would otherwise hinder the design due to complexity in the images [9], along with other image preparation techniques including morphological procedures. In this study, the implementation of the suggested preprocessing

approach is examined as well as the recommended technique's correctness. By using data from network accuracy, the Jaccard Index, the Dice score, and other performance standards that help us compare, we also compare our proposed technique to other ones that are currently in use [10].

II. LITERATURE REVIEW

This section outlines and lays out the pertinent research that has been done on the topic of segmenting skin lesions. The latest research that have used deep-learning techniques for the mentioned aim of lesion classification are given further prominence in this process. It is proposed that correct segmentation and delineation of skin lesion borders can benefit the physician at the first stages of diagnosis and detection as well as later on when classifying the lesion type.

Numerous research have been conducted in order to segment and characterize skin lesions. For a basic overview of these investigations, the reader is referred to the following two works by Oliveira et al. and Rafael et al. [11]. Following, we evaluate the literature in relation to two issues (i.e., pre-processing and segmentation techniques, respectively). Both elements fit into the larger technique discussed in this study since they have an impact on how the findings (the prediction) turn out. In order to blend out non- homogeneous parts, previous pre- processing methods must also be used since dermoscopic pictures have varied degrees of complexity and include different levels of textural, intensity, and feature inhomogeneity. The poor luminance and chaos in the photos make it difficult for investigators to segment skin conditions. The accuracy of fragmentation is impacted by these artifacts.

Celebi et al. [12] suggested a method that improves picture contrast by looking for ideal weights for transforming RGB photos into grayscale by maximizing Otsu's histogram bimodality metric. This method would produce superior results. While Beuren et al. [13] detailed the bilinear interpolation that may be performed to the picture for background subtraction, improvement led to a better adaptive capacity to discern between cancer and skin and enabled for precise resolution of the areas. The colored morphological filter highlights the lesion, and linearization is used to simply segment it. A technique to eliminate hair distortions from dermoscopic pictures was put out by Lee et al. [14].

To eliminate hair-like distortions from skin photographs, a morphological operations-based method was created. Hair, which is referred to as noise, can significantly affect segmentation outcomes when it is removed from skin pictures.

On noisy pictures, a median filter was shown to be useful. Images were smoothed using a nonlinear filter [15]. For efficient smoothing, Celebi et al., [16] states that the size of the filter to be employed must be proportionate to the size of the picture. Conventional machine learning techniques are used in the majority of picture segmentation jobs to extract features. Several key methods for precise segmentation are explained in the literature. An overview of a semi-supervised technique for separating skin lesions is given by Jaisakthi et al. [17]. For segmentation, grab-cut methods and K- means clustering are used. The latter adjusts the lesion's borders when the former divides the melanoma into smaller sections using graph cuts. Prior to feeding the input pictures to the pixel classifier, pre-processing methods including image normalization and noise reduction procedures are applied. Artificial bee colonies (ABC) were suggested by Mohanad Aljanabi et al. [18] as a technique for segmenting cutaneous lesions. The model is a swarm-based approach with fewer features that involves pre-processing of the digital pictures and finding the ideal melanoma threshold value via which the lesion is segregated using Otsu thresholding.

This method produces a high Jaccard Index and specificity. An approach for segmenting pictures using the Delaunay triangulation method was proposed by Pennisi et al. [19]. (DTM). The method uses two different pictures created by parallel classification methods, which are then combined to create the final lesion disguise. After removing artifacts from the pictures, one method

removes the skin from the images to construct a segmentation mask of the lesion, while the second method makes use of Delaunay triangulation to create the mask. To acquire the identified lesion, these two are joined. The DTM approach is quicker than other techniques since it is computerized and does not need a training phase.

In their brief survey of border detection methods (such as edge-based, region-based, histogram thresholding, active contours and clustering, etc.), M Emre Celebi et al. [34] pay particular attention to assessment factors and processing concerns.

2.1 Materials and Methods

We used dermoscopic skin pictures from two publicly available datasets—PH2 and ISIC 2017—to train and test our classification algorithm. The latter was made available by the "International Skin Imaging Collaboration" (ISIC). Figure 1 displays illustrations taken from both databases.

In the Lesion Automatic segmentation, which is the first component of the 2017 ISBI Skin Lesion Analysis approaching Melanoma Specific diagnostic, we compared our model. We compared our performance of the model with cutting-edge pipelines using the ISIC-17 test set, which consisted of 600 photos.

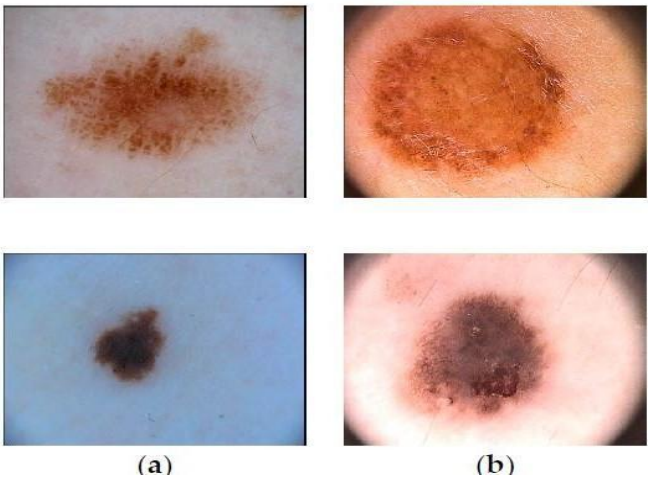

Figure 1: Examples of the ISIC-17 Dataset (A) and PH2 Dataset (B)

Additionally, the PH2 dataset, which contains 200 dermoscopic pictures, comprising 40 melanoma, 80 normal nevi, and 80 atypical nevi images, was used to evaluate our model. We describe our developed approach and the outcomes that followed after it was trained and evaluated on the datasets (details will be provided later). It is important to note right away that we presented an approach, also known as the intersecting over unity overlapping that outperforms other comparable methods, both in terms of model correctness and in pixel-by-pixel clustering algorithm (sometimes also referred to as the Jaccard Index). We now go on to detail each portion of the suggested technique, point by point. Before being used as input by the CNN model, images are first processed using procedures including resizing, scaling, hair removal, and data centered. Morphological techniques are used to remove noise. We used the following pre-processing techniques, and we saw encouraging results. Prior to feeding photographs into the neural network, it is a good idea to resize the images. It enables the model to convolve more quickly, reducing computing time and addressing memory limitations. Dermoscopic pictures arrive in different sizes, therefore to account for these individual variations, the images and the ground truths they correspond to are down sampled to 256 256 resolution. The labels for each RBG picture are in the PNG file format, whereas all of the RGB images are in the JPEG file format.

Image normalization and standardization: To eliminate concerns with weak contrast, images are normalized prior to training. By rescaling the

picture between 0 and 1, or normalizing the image's pixel values, the input data is centered on zero in all dimensions. The picture is normalized by deducting it from its mean value, which is then multiplied by the image's standard deviation.

III. MODEL ARCHITECTURE

Visual identification and object detection issues are now being solved using deep learning systems. For feature extraction, CNN models have demonstrated superior performance than semi-automated techniques. The encoder-decoder-based U-Net architecture has produced noteworthy outcomes in the segmentation of medical images. These networks provide binary classification models as their output. CNN models often consist of a mix of layers (i.e., convolutional, max pooling, batch normalization, and activation layer). The usage of Deep learning architectures in computer aided medical diagnosis is common.

A Convolution layer was developed for this purpose using the ISIC 2017 dataset. Both U-Net and ResNet are used as inspiration for the network design (as illustrated in Figure 3). The U-Net pipeline serves as the foundation for the expanding path (deconvolutional side), while the ResNet framework serves as the foundation for the training part (convolutional side). The network has 50 layers overall and operates in an encoder-decoder mode (ResNet-50). Enter 256 x 256 resolution pictures.

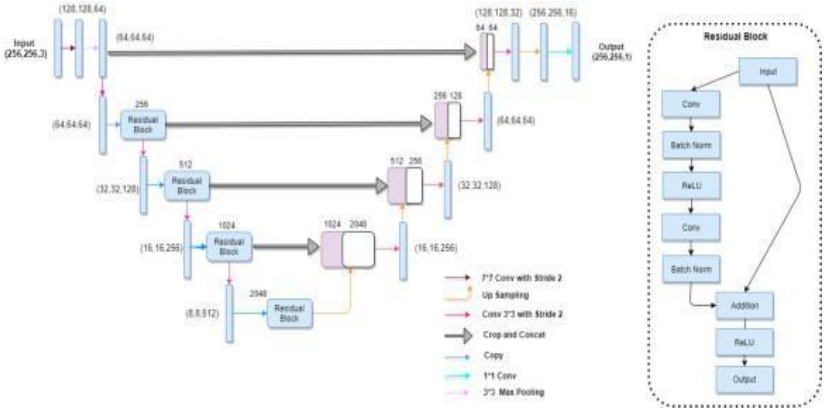

Figure 2: Schematic Diagram Representing UResNet-50. the ResNet-50 Encoder Is Displayed on the Left, While the U-Net Decoding Is Displayed on the Right. the Channel Widths of the Receiving Extracted Features to Each Square Are Provided in the Parentheses

On the expanding side, a max pooling layer with a kernel of 3 x 3 and a stride of 2 that divides the input width in half is constructed after the initial convolutional layer. 3 convolutional layers per repeating block are inserted; the 1 x 1 convolution layer is designated before and after each 3 x 3 convolution operation. Prior to the 3 x 3 convolutional layer, the amount of input channels is decreased, and once more, the 1 x 1 is established to restore proportions. This so-called "bottleneck" design shortens the network's training period. We trained our model for 100 iterations and used data augmentation during runtime, which improves performance since additional data increases the reliability of the algorithm so that it can categorize more accurately, having a major impact on the classification outcomes. We tripled the dataset by rotating the photos in 3 components. In the event that the model damage does not reduce after 10 epochs, early ending is established, and the learning rate is decreased. Our model came to an end after about 70 epochs. Employing pre-trained weights acquired during training on the ImageNet dataset, deep learning was used to train the model on our set of data.

IV. RESULTS AND DISCUSSION

The International Skin Imaging Collaboration ISIC 2017 provided the pictures used to assess our model. The ISIC 2017 training set, which

included 2000 photos of skin lesions, served as the basis for our CNN model's training. This procedure resulted in a 70-epoch overall training accuracy of 0.995. Figure 3 highlights how the training group's accuracy varied from the validation group's during training.

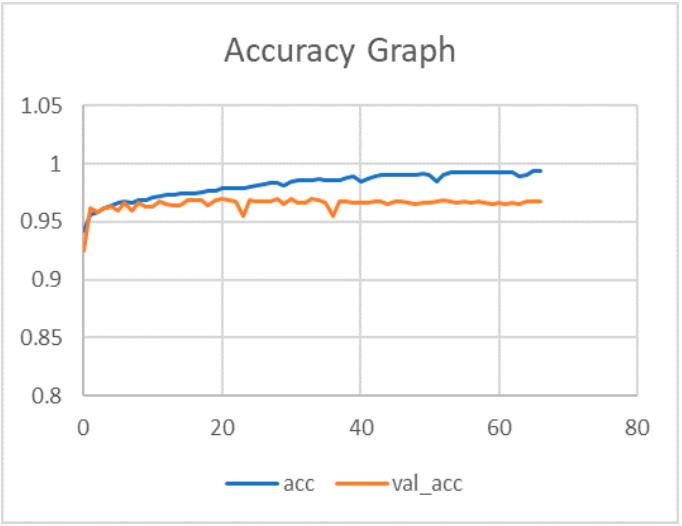

Figure 3: Training and Validation Accuracy of the Proposed Convolutional Neural Network Model for 70 Epochs

The validation and test set from the ISIC 2017 dataset were used to test the model. Additionally, the model was assessed using the PH2 dataset, which consists of 200 dermoscopic pictures. The effectiveness of the suggested CNN model could also be evaluated using the ground facts that were also accessible. Before being input into the CNN architecture as shown in Figure 3, all pictures underwent pre-processing. Accuracy of the suggested convolutional model of neural networks for 70 iterations during training and validation. Convolutional layer characteristics were specified during the training phase. The model parameters were left alone throughout the assessment procedure in order to gauge how well our model performed given the initial values.

Figure 4 displays the outcomes of several patients. To assess the effectiveness of binary classifiers, the receiver operating characteristics (ROC) curve was utilized. A plot of the true positive rate (Sensitivity) against the false positive rate (Specificity) at various thresholds is known as a ROC. In this study, the lesion area is segmented, with 1 denoting the lesion region and 0 denoting the black portion of the picture. The ROC curve is the best evaluation method for determining class separability. A curve's individual data points each display values at a certain threshold.

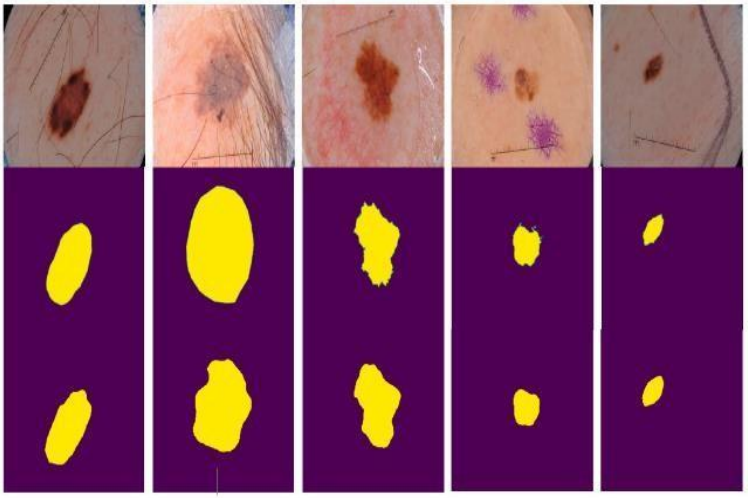

Figure 4: Example Results of Various Images

To determine the effectiveness of the hair removal method, the model was evaluated on the ISIC-17 dataset both with and without pre-processing.

When the inpainting approach was not used to remove the hair structures from the pictures, a Jaccard of 0.763 (as shown in Table 4) was obtained. This value increased significantly to 0.772 with the use of the pre-processing technique. The goal was to more accurately segregate the lesion locations using this study than with previous techniques. Our network was tested against three different sets of images: the PH2 dataset, the ISIC 2017 test group, and the ISIC 2017 validation group. There were 150 dermoscopic pictures in the validation group and 600 in the test group. The PH2 dataset, which is a well-known dataset, was employed to further assess our network and compare the findings to those of other competing methods and challenge members.

V. CONCLUSION

In order to create a computer assisted diagnosis system for skin cancer, skin lesion segmentation is a crucial step. In this study, we successfully created a CNN-based skin lesion segmentation algorithm that deleted hair structures from the dermoscopic pictures, greatly increasing accuracy. The Jaccard indices we got from the ISIC-2017 dataset and the PH2 dataset, on which we evaluated our model architecture, were 0.772 and 0.854, respectively. When compared to cutting-edge methods in terms of the Jaccard index, our suggested strategy produced encouraging results. Additionally, our CNN model outperformed the existing approaches in the literature when evaluated on the PH2 dataset and the ISIC-17 test set. It also yielded superior segmentation. According to empirical findings, the U-Net and ResNet combo produces excellent outcomes. To minimize the model from imbalanced datasets, the small amount of training data utilized must be heavily supplemented. Therefore, a huge dataset is required for the model to be more accurate and broader. Additionally, the model was designed to be complicated and effective in order to produce state-of-the-art outcomes, which requires more time to train than the traditional U-Net. In order to alleviate overfitting issues, we will be employing a larger dataset in the future. We will also be hyper- tuning the model parameters. The developed model can also be improved using a conditional random field (CRF) approach.

Author Biography

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He was honored with "Fellow of Computer Science Research Council (FCSRC)" from Open Association of Research Society from Global Journals, U.S.A) on 31st January 2019 for the performance of published research work in the world. He was awarded with "Best Outstanding Researcher 2020" International Award and Best Outstanding Scientists 2020 with Gold Medal, Memento and Certificate from Kamarajar Institute of Higher Education Theme, Madurai-Tamil Nadu. Also, he received "Best Outstanding Scientists 2021" International award from International Scientists on Science, Engineering & Medicine 2021, VDGOODTM TECHNOLOGY FACTORY, Coimbatore-Tamilnadu.

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