Athens Journal of Health and Medical Sciences

Quarterly Academic Periodical,
Volume 10, Issue 4, December 2023
URL: https://www.athensjournals.gr/ajh
Email: journals@atiner.gr
e-ISSN: 2241-8229 DOI: 10.30958/ajhms

Athens Journal of Health and Medical Sciences

Published by the Athens Institute for Education and Research (ATINER)

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The Athens Journal of Health and Medical Sciences
ISSN NUMBER: 2241-8229 - DOI: 10.30958/ajhms
Volume 10, Issue 4, December 2023
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Athens Journal of Health and Medical Sciences
Editorial and Reviewers' Board

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The current issue is the fourth of the tenth volume of the *Athens Journal of Health and Medical Sciences* (AJHMS), published by the **Health & Medical Sciences Division of ATINER.**

Gregory T. Papanikos
President
ATINER

Athens Institute for Education and Research

A World Association of Academics and Researchers

23rd Annual International Conference on Health Economics, Management & Policy, 24-27 June 2024, Athens, Greece

The Health Economics & Management Unit of ATINER will hold its **23rd Annual International Conference on Health Economics, Management & Policy, 24-27 June 2024, Athens, Greece s**ponsored by the Athens Journal of Health and Medical Sciences. The aim of the conference is to bring together academics, researchers and professionals in health economics, management and policy. You may participate as stream leader, presenter of one paper, chair of a session or observer. Please submit a proposal using the form available (https://www.atiner.gr/2024/FORM-HEA.doc).

Academic Members Responsible for the Conference

- **Dr. Paul Contoyannis**, Head, Health Economics & Management Unit, ATINER & Associate Professor, McMaster University, Canada.
- **Dr. Vickie Hughes**, Director, Health & Medical Sciences Division, ATINER & Assistant Professor, School of Nursing, Johns Hopkins University, USA.

Important Dates

- Abstract Submission: **5 March 2024**
- Acceptance of Abstract: 4 Weeks after Submission
- Submission of Paper: **27 May 2024**

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6-9 May 2024, Athens, Greece

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Important Dates

- Abstract Submission: **16 January 2024**
- Acceptance of Abstract: 4 Weeks after Submission
- Submission of Paper: **8 April 2024**

Academic Member Responsible for the Conference

- **Dr. Vickie Hughes**, Director, Health & Medical Sciences Research Division, ATINER & Assistant Professor, School of Nursing, Johns Hopkins University, USA.
- **Dr. Carol Anne Chamley**, Head, Nursing Research Unit & Associate Professor, School of Health and Social Care, London South Bank University UK.
- **Dr. Andriana Margariti**, Head, Medicine Research Unit, ATINER & Lecturer, Centre for Experimental Medicine, Queen's University Belfast, U.K.

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A Research Study on Comparison of Prevalence and Outcome of Maxillofacial Odontogenic Space Infection between Diabetic and Non-Diabetic Patients

By Shahid Ali[*], Wares Uddin[±], Gupta Siddharth[•] & Rajesh Sah[°]

***Background**: Orofacial space infections are commonly encountered problems in dental practice. The highest prevalence is seen among South Asian population because of their negligence in seeking dental treatment. Diabetes is one of the most common systemic illnesses suppressing the immunity of individual and increasing their susceptibility to infections. Currently, immunocompromised situation (Diabetes mellitus) and space infection together leads to complexity to evaluate the overall outcome of the patients. **Objective**: Aim of this study is to compare the prevalence and outcome of maxillofacial odontogenic space infection between diabetic and non-diabetic patients. **Materials and Methods:** This cross sectional study was conducted in the Department of Oral and Maxillofacial Surgery, BSMMU and DMCH over a period of 15 Months, from June 2020 to August 2021.The selection of the patients was as per the inclusion and exclusion criteria. The study commenced after IRB clearance. All the patients enrolled in this study after proper counseling and informed written consent. A total of 63 patients were taken and divided in to two groups on the basis of presence or absence of diabetes mellitus, Group A (diabetic): N1 number of patients and Group B (non-diabetic): N2 number of patients. **Results:** Majority of the patients were from BSMMU (58.73%) followed by DMCH (41.26%). Male were more commonly affected than females. Submandibular space was most commonly involved. Streptococcus was the most commonly isolated organism in non-diabetics while Klebsiella in diabetic patients. Meropenem was the most sensitive antibiotic while Amoxicillin was least sensitive antibiotic against the organisms found. This data will be helpful for future research and that will be considered baseline information for public health department. **Conclusion:** Prevalence of MSI was 4.33 (per thousand) in the study centers of Dhaka. Submandibular space was most common involved space in both diabetic and non-diabetic patients. Streptococcus was the most commonly isolated organism in non-diabetics while Klebsiellain diabetic patients. Meropenam was the most sensitive antibiotic in both group while Amoxicillin was not found sensitive on any patient in group A while least sensitive in group B.*

Keywords: *odontogenic infection, fascial spaces, culture and antibiotic sensitivity*

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Introduction

Head and neck tissues commonly represent the site of several non-specific infections with various degrees of severity. This localization is favored by the presence of oral cavity and of pharyngeal structure, which, because of exposure of high level of bacterial flora, are frequently the starting point of these conditions (Fragiskos 2007).

Among them spreading odontogenic infections are the most common type of serious oral and maxillofacial infections and range from the periapical abscess to superficial and deep neck abscess. Maxillofacial spaces have been defined and described by Urns in 1811 as potential spaces between the layers of fascia. These spaces are filled with loose connective tissues and numerous anatomical structures like veins, arteries, glands, lymph nodes (Holkom 2020).

Odontogenic infections contribute to Maxillofacial Space Infection (*MSI*) in the range of 50–89% in reports from different parts of the world (George et al. 2012). There were 50% odontogenic infections in 185 cases of deep neck infections in Taiwan and diabetic have increased range of MSI that was 88.9% (Huang et al. 2005), 56.1% among 212 cases of *MSI* in China (Zheng et al. 2012), 89% in their 121 cases of Ludwig's angina, Mexico, (Bross-Soriano et al. 2004), 2.85% cases with Ludwig's angina in 210 cases of maxillofacial infections in Brazil (Sato et al. 2009) and 6.25% in 48 cases of severe space infections (Uluibau et al. 2000). An increasing proportion of odontogenic cause among deep neck abscesses over the years has been reported and range of *MSI* increased by 50% among diabetic patients (Parhiscar and Har-El 2001).

MSI are caused by the sequela of dental caries, periodontal disease and even by trauma. Periapical lesion and periodontal lesions are considered as the foremost causes of facial infection which may arise as iotrogenic complications of tooth extraction or local anesthesia (Holkom et al. 2020). Odontogenic infections are typically polymicrobial in nature. It may be due to the fact that the oral cavity contains a complex population of microorganisms. However, the anaerobes generally outnumber the aerobic bacteria by a factor of three to four folds (Sands and Markus 1995). The etiology is usually a presence of decayed or contiguous non-vital teeth, postoperative infections, periodontal disease andpericoronitis. If dismissed, they generally spread into fascial spaces and may lead to adverse life-threatening consequences (Shakya et al. 2017).

Diagnostic work-up includes proper history taking, close clinical examination certain investigations like OPG, contrast CT, USG, MRI, Culture and Sensitivity. Diagnosis should include the spaces involved, severity of infections, virulence of microorganisms.USG is quick, inexpensive, painless and is valuable diagnostic aid to the oral and maxillofacial surgeon for early and accurate diagnosis of facial space infection, their appropriate treatment and to limit their further spread (Bali et al. 2015). Enhanced contrast CT is valuable for detecting either the infection is odontogenic or non odontogenic (Kim et al. 1997). However MRI is considered to be more superior to CT in regard to lesion conspicuity, extension, number of anatomic spaces involved and source on infection (Ikkurthi et al. 2018).

Different strategies have been adopted for the management of odontogenic space infections. Some of these infections resolve with little consequences, while some may spread to facial spaces adjacent to the oral cavity and spread aggressively leading to more severe infections (Chunduri et al. 2012).

Several antibiotics are indicated for odontiogenic infections. Proper understanding of disease process, treatment plan, mode of action of antibiotics, patient's health status, pharmacokinetics and dose of the antibiotics is essential for a successful treatment outcome. The orally administered antibiotics are effective against odontogenic infections. They include amoxicillin, metronidazole, clindamycin etc. (FC 2016). However, if these infections are ignored or not treated properly, complications such as airway obstructions, infection of carotid sheath, meningitis, septicemia, cavernous sinus thrombosis, mediastinitis and distant metastatic foci have been reported.

Some reports reveal Streptococcusas the major causative organism for infection, whereas a few have *Klebsiella Pneumonia*thepredominate causative organisms.

Odontogenic infections most of the times seems to be associated with co-morbid conditions like diabetes mellitus, hypertension and renal disease. Among them diabetes mellitus is recognized as the most common associated systemic disease in deep neck infections (Parhiscar and Har-El 2001). The clinical studies performed so far have emphasized a frequent association between diabetes and the occurrence of severe head and neck infections such as necrotizing fasciitis (Flynn et al. 2006).

The patients with deep neck infection who have diabetes mellitus usually display a unique clinical picture in comparison with those without diabetes mellitus (Chen et al. 2000).

The prevalence of diabetes is increasing worldwide with diabetic individuals usually having higher predisposition to infections. Infections represent a frequent and severe systemic complication of diabetes mellitus and are said to be associated with sustained hyperglycemia (Pozzilli and Leslie 1994). In addition to impaired host defense mechanism, other factors may also increase the susceptibility of diabetic patients to infection. In odontogenic infections it has been documented that the organisms that affect diabetic individuals might be different from those in individuals who are not diabetic (Huang et al. 2005).

There are certain pathogenic mechanisms that make diabetic patients more susceptible to infection. It includes hyperglycemic environment increasing the virulence of some pathogens; lower production of interleukins in response to infection; reduced chemotaxis and phagocytic activity; immobilization of polymorph nuclear leukocytes; glycosuria, gastrointestinal and urinary dysmotility (Alves et al. 2012).

In short all these effects are caused by hyperglycemia. Hyperglycemia causes proteinglycation and formation of advanced glycation end products, which can have a diverse impact on host cell function (Sathasivam 2018). It can cause impairment of host proteins involved in complement activation, bacterial uptake, phagocytic killing and scavenging of bio limiting nutrients and change the binding of host surface receptors for pathogens (Gan 2013).

The aim of the study will be to highlight the comparison of frequency and outcome of maxillofacial space infections in diabetic and non-diabetic patients. The corner stone of management of infections in the oral and maxillofacial region remains the same in diabetic and non-diabetic patients i.e., source, infection control, drainage and adjunctive antimicrobial therapy. In light of this, a study will be conducted to compare the prevalence, odontogenic spaces involved, microorganism involvement and antibiotic susceptibility between diabetic and non-diabetic.

Rationale

Maxillofacial infections are most frequently occurring infectious processes known to both antiquity and present-day health practice which ranges from periapical abscess to superficial and deep neck abscess. The annual estimated prevalence of MSI is 50-89% from different part of the world. There are wide geographical variations in the prevalence of MSI and is more commonly seen in developing countries.

This study was design to see the prevalence of MSI in both Diabetic and non-diabetic patients. The spaces commonly involved in MSI. The most common organisms involved and the sensitive antibiotics against those organisms.

Globally, the burden of diabetes is increasing very rapidly as its related complications. Infections in diabetes mellitus are relatively more common and serious. There is no previous study of maxillofacial space infections comparing between diabetic and non-diabetic patients in Bangladesh. This study will give a new insight of maxillofacial space infection originating from dental origin comparing the outcome between diabetic and non-diabetic patients.

Research Question

Are there any differences on prevalence and outcome of maxillofacial odontogenic space infections between diabetic and non-diabetic patients?

Objectives

General Objective

To compare the prevalence and outcome of maxillofacial odontogenic space infection between diabetic and non-diabetic patients.

Specific Objectives

- To determine the prevalence of space infection in both diabetic and non-diabetic patients.
- To determine the maxillofacial spaces involved in both diabetic and non-diabetic patients.
- To assess the microorganisms involved in maxillofacial space infections in both diabetic and non-diabetic patients

- To evaluate the antibiotic sensitivity profile of both diabetic and non-diabetic patients having maxillofacial space infection.

Literature Review

A retrospective study among 131 patients was conducted by Lin et al. (2006) on influence of diabetes mellitus on deep neck infection. Prevalence rate of infection was greater in diabetes mellitus. Klebsiella was most common isolated organism and more than 2 spaces involvement was common among diabetic patients.

Rao et al. (2010) conducted a 4 years retrospective study of comparison of Maxillofacial space infection in diabetic and non-diabetic patients among the 111 patients. Among them they found 31 patients were diabetic and 80 were non-diabetic. The organism most commonly isolated were streptococcus species with submandibular space being the most common space in both groups.

George et al. (2012) conducted a 5 years retrospective study of odontogenic maxillofacial space infection at a tertiary center in North India among 137 patients. Among them 24.1% were diabetic. Submandibular space was commonly involved.

A 10 years retrospective study on prevalence of odontogenic deep head and neck space infection and its correlation with length of hospital stay by Zamiri et al. (2012). Among total of 297 patients, 34.3% (n=102) were odontogenic origin. Middle class families were more commonly affected. Sub-mandibular space was most commonly involved (32%). Non-hemolytic streptococcus was most common isolated organism.

A two year retrospective study was conducted by Chang et al. (2013) among fifty-one (51) patients to evaluate the clinical impacts of diabetes mellitus on prognosis in comparing non-diabetic patients. In the study twenty-five (25) patients were diabetic and twenty-six (26) were non-diabetic. In diabetic patients more space were involved, being the masseteric, pterygomandibular and temporal spaces were the secondary spaces were mainly involved.

A case control study by Juncar et al. (2014) a retrospective study over a period of 10 years in 899 patients with 79 patients in diabetic group and 826 patients in non-diabetic group. In the study old aged patients were more commonly affected in both groups. There were 34% cases involving single space only in diabetic groups and 86.8% in non-diabetic groups. The most common isolated organism was staphylococcus aureus, followed by streptococcus and E.coli in both the groups.

A comparative analysis of odontogenic maxillofacial infections in diabetic and non-diabetic patients, an institutional study was evaluated by Rahul et al. (2015) among 188 patients for 2 years and concluded that 61 patients were diabetic and 127 patients were non-diabetic with MSI. The submandibular space was the most commonly involved space, and the most common organism was Klebsiella in diabetic and streptococcus in non-diabetic group.

A retrospective study of 270 cases of deep neck space infection at tertiary care center by Gujrathi et al. (2016) where males were commonly affected. Streptococcus and Staphylococcus species were most commonly isolated organism.

Sultana et al. (2017) conducted study on etiology of deep neck infection and determination of their predisposition factors and microbial pattern. The study concluded Streptococcal species was most common isolated organism followed by *Klebseilla*and *Staphylococcus.*

In a study conducted by Shah et al. (2016), among 100 patients on aerobic microbiology and culture of head and neck space infection of odontogenic origin. aerobic gram positive was isolated among 73% and aerobic gram negative among 18% patients while no growth was detected among 9% patients. *Streptococcus* was most common involved organism in gram positive cases while *Kleibsella* was found maximum in overall patients. Amoxicillin was most resistance (48.4%) comparing ceftriaxone, carbenicillin and amikacin.

Shakya et al. (2017) conducted study on epidemiology, microbiology, antibitotic sensitivity of odontogenic space infection in central India among 100 cases. Male were more commonly affected. Sub mandibular space was most common involved (44.26%) followed by buccal space (27%). Streptococcus was most common isolated organism (47.05) followed by staphylococcus. Amoxicillin with clavunate and clindamycin was the most effective antibiotic against those organisms.

An study on analysis of maxillofacial and neck spaces infection by Holkom et al. (2020) in diabetic and non-diabetic patients was conducted for 4 years in 120 cases where 47 patients found to be diabetic and 73 patients were non-diabetic, Among the study population it was concluded that 53% were female and 45% were male. Multiple spaces were more common in diabetic groups comparing to non-diabetic groups. Submandibular space was most common space in both the groups followed by buccal and masseteric space. Streptococcus species was the most common isolated organism in both the groups.

Materials and Methods

Type of Study

Observational analytical study

Place of Study

Department of Oral and Maxillofacial Surgery
Bangabandhu Sheikh Mujib Medical University (BSMMU) and
Dhaka Medical College and Hospital (DMCH)

Period of Study

June 2020 to August 2021 (15 Months)

Study Population

The study population comprised of patients having maxillofacial space infections associated with other conditions.

Study Sample

Patients having Maxillofacial space infections with or without diabetes mellitus presenting to the department of oral and maxillofacial surgery, Bangabandhu Sheikh Mujib Medical University and Dhaka Medical College and Hospital, Dhaka.

Sampling Technique

Consecutive sampling: Total 63 patients assigned by consecutive sampling technique patients and divided in to 2 groups.

Sample Size

According to the **Morgan's table** for sample size, if the population size is 70 then by considering **5%** of margin of error, sample size will be **63**.

Grouping of the Sample

Total sample size of the study as per calculation was 63 which was divided in to following 2 groups.

Group A - This group consists of N1 number of Maxillofacial space infection patients with diabetes mellitus.

Group B - This group consists of N2 number of Maxillofacial space infection patients without diabetes mellitus.

Selection Criteria

Inclusion Criteria

- Patient with MSI either diabetic or non-diabetic.
- Patient who has given consent will be included in this study
- Both gender
- Any age patients

Exclusion Criteria

- Patient with other pathological findings in maxillofacial region rather than space infections.
- Patients with head and neck space infection of non-odontogenic origin.
- Patients with antibiotic intake before reporting.

Immuno-compromised patient other than diabetes mellitus

Patents who refuse to give written consent

Variables of the Study

Demographic Variables

- Age
- Gender
- Educational status
- Socio-economic status

Outcome Variables

- Prevalence
- Spaces involved
- Causative organism
- Antibiotic sensitivity

Operational Definitions

Orofacial Space Infection

Space infections are potential spaces between the fascias. The clinical spectrum of orofacial infections affecting the skin or mucous membrane of the face and oral cavity is quite diverse. Such infections may be localized and indolent, or invasive and life-threatening. These infections may be conveniently categorized as odontogenic and non-odontogenic.

Odontogenic Infection

An odontogenic infection is an infection that originates within a tooth or in the closely surrounding tissues. The term is derived from odonto- (from ancient Greek odontos - "tooth") and -genic (from Greek genos - "birth").

Diabetes Mellitus

Diabetes mellitus (DM), commonly known as diabetes, a chronic disease associated with abnormally high level of sugar glucose in the blood due to inadequate production of insulin (which is made by the pancreas and lowers blood glucose) or inadequate sensitivity of cells to the action of insulin and is a group of metabolic disorders characterized by high blood sugar levels over a prolonged period.

Antibiotic Sensitivity Test

An antibiotic sensitivity (or susceptibility) test is done to help chose the antibiotic that will most effective against the specific type of bacteria infecting an individual person that is because by resistant bacteria are not cured by treatment with those antibiotics. This method is also called the agar diffusion method or the disk diffusion method. The procedure followed is simply that a filter disk impregnated with an antibiotic is applied to the surface of an agar plate containing the organism to be tested and the plate is incubated at 37°C for 24-48 hours.

Pus Culture

A sample of pus is added to a substance which promotes the growth of microorganisms. If no microorganisms grow, the culture is said to be negative. On the other hand, if the microorganisms that can cause infection to grow, the culture is said to be positive.

Wound infections may be caused by one to many organisms depending on the site of the infection

Gram positive	**Gram negative**
Staphylococcus aureus	*Pseudomonas aeruginosa*
Streptococcus pyogenes	*Escherichia coli*
Enterococcus species	*Proteus* species
Anaerobic streptococci	Klebseillaspecies
Other streptococci	Bacteriodes species

Deep Neck Infection

A deep neck infection (neck abscess) is a collection of pus from an infection in spaces between the structures of the neck. Deep neck infections (DNI) can originate from infection in the potential spaces and fascial planes.

Incision and Drainage

It can be defined as process to release pus or pressure built up under the skin, such as from an abscess, boil or infected paranasal sinus.

Socio-economic condition:

According to Asian Development Bank
Less than 2$ per day = poor family
2$ to 20$ per day= middle class family
More than 20$ per day= high class family

Study Procedure

Detailed history was taken, and clinical examinations were done for each patient and recorded in pre-designed data entry sheet. Study data (Demographic characteristics, Space infection characteristics, radiological examinations) were recorded.

Specimen was collected before antimicrobial therapy and/or before application of antiseptic dressing. Minimum volume of 1ml (up to 5 ml) of pus was collected in a sterile syringe – any air bubble was expelled. Syringe safely and tightly capped (needle was not sent).

The specimen was labeled and deliver to the laboratory as soon as possible with a completed request form.

Data Collection

The study subjects were selected on the basis of selection criteria from the patients presenting at Department of Oral and Maxillofacial Surgery, Bangabandhu Sheikh Mujib Medical University (BSMMU) and Dhaka Medical College and Hospital (DMCH). The demographic information, relevant history, examination findings and investigation reports of all the study subjects was recorded in the pre-designed data collection sheet.

Data Collection Tools

Pre-determined data collection sheet, filled up by the investigator himself through interview, supplemented by documentary evidence (imaging).

Data Analysis

The data were analyzed using the Statistical Package for the Socials Sciences (SPSS) version 24 (IBM Corporation, Armonk, NY, USA). Demographic variables were presented by means of frequency and percentages. Categorical variables were analyzed between 2 groups by Chi-square test and Fisher's exact test whereas continuous variables between 2 groups were measured by Student's *t* test (unpaired). Level of significance was considered as $p<0.05$.

Ethical Consideration

Ethical clearance for the study was taken and obtained from the Institutional Review Board (I.R.B) of BSMMU prior to the commencement of this study. After the research protocol is approved by the committee, permission for the study was taken from the Department of Oral and Maxillofacial Surgery, Bangabandhu Sheikh Mujib Medical University and Department of Pathology, Bangabandhu Sheikh Mujib Medical University. (**Ethical IRB Number: BSMMU-2020/10144**) held in the 209th meeting on 17th October 2020.

The aims and objectives of the study along with its procedure, risks, Stages and benefits of this study was explained to the study subjects in an easily understandable local language. A written informed consent was taken from all the study subjects without exploiting any of their weakness.

All the study subjects were assured about their confidentiality and freedom to withdraw themselves from the study at any time.

Results

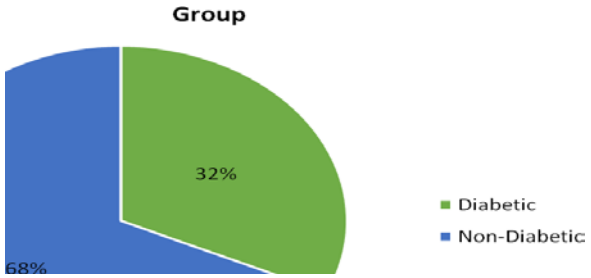
Prevalence of Maxillofacial Space Infection

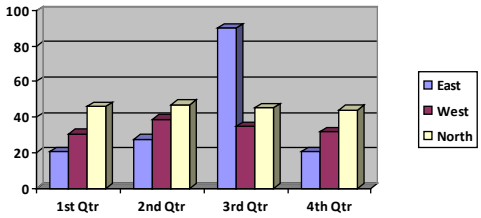
Table 1 and Figure 1 show the total cases presented at department of OMFS were 14877. Among those, 63 were cases of MSI. Current prevalence of MSI at study centers of Dhaka is 4.23 (Per thousand).

Table 1. *Prevalence of Maxillofacial Space Infection*

Study Centers	Number of cases Presented at OPD	Diagnosed as Maxillofacial space Infection	Prevalence (per thousand)
BSMMU	8535	37	4.33
DMCH	6342	26	4.09
TOTAL	14877	63	4.23

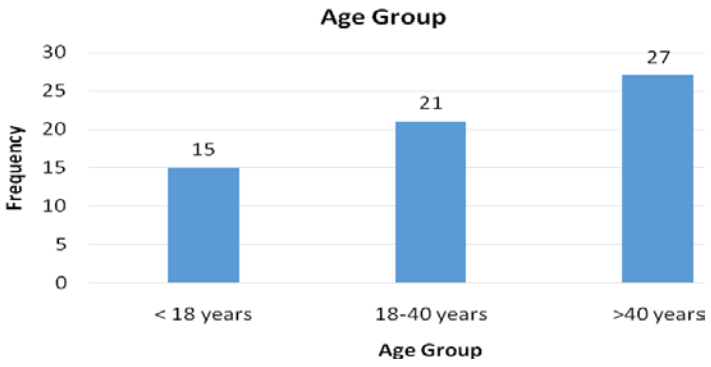
Figure 1. *Pie Chart Showing Distribution of Patients by Diabetic Status. Pie Chart Shows 32% Patients Were Diabetic while 68 % Patients Were Non-Diabetic in the Study Population*





Distribution of Patients by Age Group

Figure 2. *Bar Diagram Showing Distribution of Patients by Age Group (N=63)*



The above bar diagram shows>40 years of age group consists majority patients 27 (42%) while<18 years of age consists minimum patients 15 (34%).

Table 2 and Figure 2 show majority of the patients in group A were aged > 40 years 14 (70%) followed by (18-40) years of age 6 (30%). No patient in group A was below 18 years of age. In group B <18 years and (18-40) years of age consists equal number of patients 15 (34.88%) followed by 13 (30.2%) patients in > 40 years of age group. Patients distribution among both group by age was statistically highly significant (*p<0.001).*

Table 2. *Distribution of Patients by Age Group (N=63)*

Age Group	**Group A (n_1=20)**		**Group B (n_2=43)**		***p**-value**
	n_1	**%**	**n_2**	**%**	
< 18 years	0	0	15	34.88	
18-40 years	6	30	15	34.88	
>40 years	14	70	13	30.2	
Mean ± SD	53.43±12.17		49.31±9.39		0.001[s]

s=significant

**p*-value reached by unpaired Student's *t*-test and considered significant $p<0.05$.

Gender

Figure 3. *Chart Showing Distribution of Patients by Gender (N=63)*

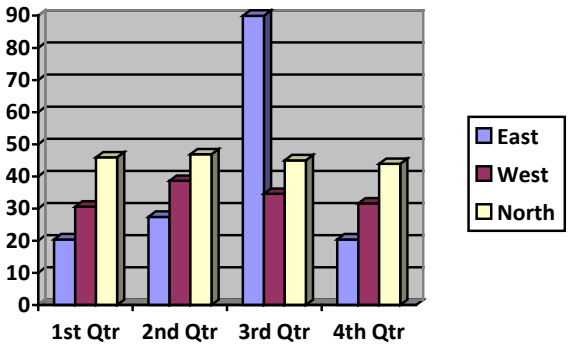


Table 3 and Figure 3 show pre-dominancy of the male patients 38 (60%) in comparison to the female patients 25 (39.6%) in the study population.

There were more male patients in both group A 11 (55%) and B 27 (62.8%) in comparison to female patients, A 9 (45%) and B 16 (37.2%). Patients distribution among both group by gender was statistically non- significant (*p=0.375).*

Table 3. *Distribution of Patients by Gender (n=63)*

Gender	**Group A (n_1=20)**		**Group B (n_2=43)**		***p*-*value**
	n_1	**%**	**n_2**	**%**	
Male	11	55	27	62.8	0.375[ns]
Female	9	45	16	37.2	

ns=non-significant

**p*-value reached by Pearson Chi-Square test and considered significant when $p<0.05$.

Educational Status

Figure 4. *Pie Chart Showing Distribution of Patients by Educational Status (n=63)*

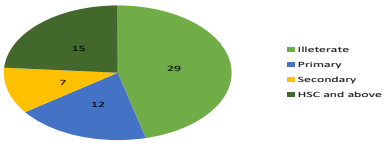


Table 4 and Figure 4 show majority of patients were illiterate 29 (46%) while minimum patients had primary level education 12 (19%) in the study population.

Table 4 also shows majority of the patients in group A were educated (HSC and above) followed by equal number of patients in Illiterate and primary level category 4 (20%). In group B illiteracy rate was found in majority of patients 25 (58.1%) followed by primary level education 8 (18.6%). Minimum number of patients from both group A 3 (15%) and group B 4 (9.3%) were from secondary level education. Patients distribution among both group by educational status was statistically significant (*p=0.017).*

Table 4. *Distribution of Patients by Educational Status (n=63)*

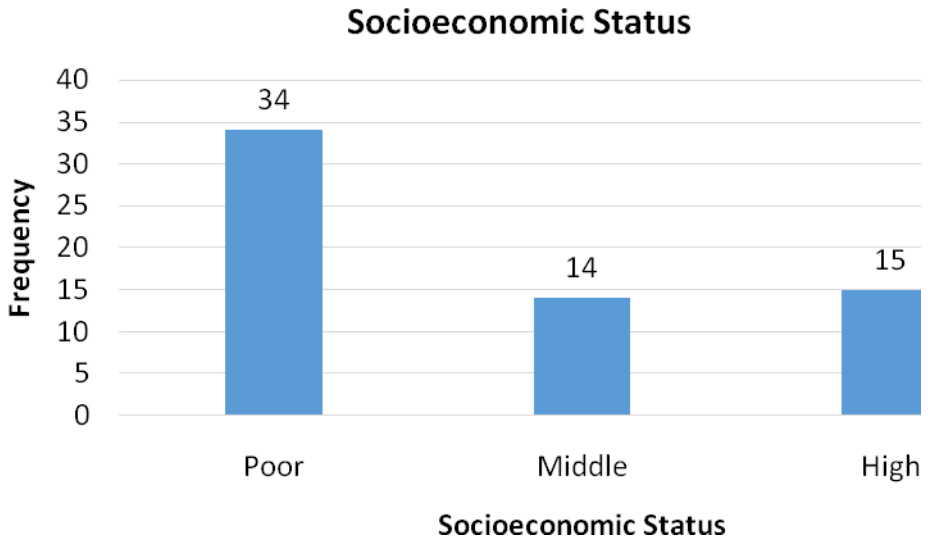
Educational Status	**Group A (n_1=20)**		**Group B (n_2=43)**		***p**-value**
	n_1	**%**	**n_2**	**%**	
Illiterate	4	20.0	25	58.1	0.017[S]
Primary	4	20.0	8	18.6	
Secondary	3	15	4	9.3	
HSC and above	9	45	6	14	

S=significant

**p*-value reached by Pearson Chi-Square test and considered significant when $p<0.05$.

Socio-Economic Condition

Figure 5. *Bar Diagram Showing Distribution of Patients by Socio-Economic Condition (n=63)*



Majority of patients were from poor society 34 (53.96%) while middle- and high-class patients have almost equal incidence of involvement 14 (22.22%) and 15 (23.80%) respectively (Table 5, Figure 5).

Group A consists 10 (50%), 6 (30%) and 4 (20%) number of patients in high, middle and low-class society, respectively. In group B majority of patients belongs to low class society 30 (69.8%) followed by middle class 8 (18.6%) and then high class society 5 (11.6%).Patients distribution among both group by socio-economic condition was statistically highly significant (*p<0.001).*

Table 5. *Distribution of Patients by Their Socio-Economic Condition (n=63)*

Socio-economic condition	**Group A (n_1=20)**		**Group B (n_2=43)**		***p**-value**
	n_1	**%**	**n_2**	**%**	
Low	4	20	30	69.8	0.001[s]
Middle	6	30	8	18.6	
High	10	50	5	11.6	

s=significant

**p*-value reached by Pearson Chi-Square test and considered significant when $p<0.05$.

Space Involvement

Figure 6. *Distribution of Patients by Spaces Involvement (n=63)*

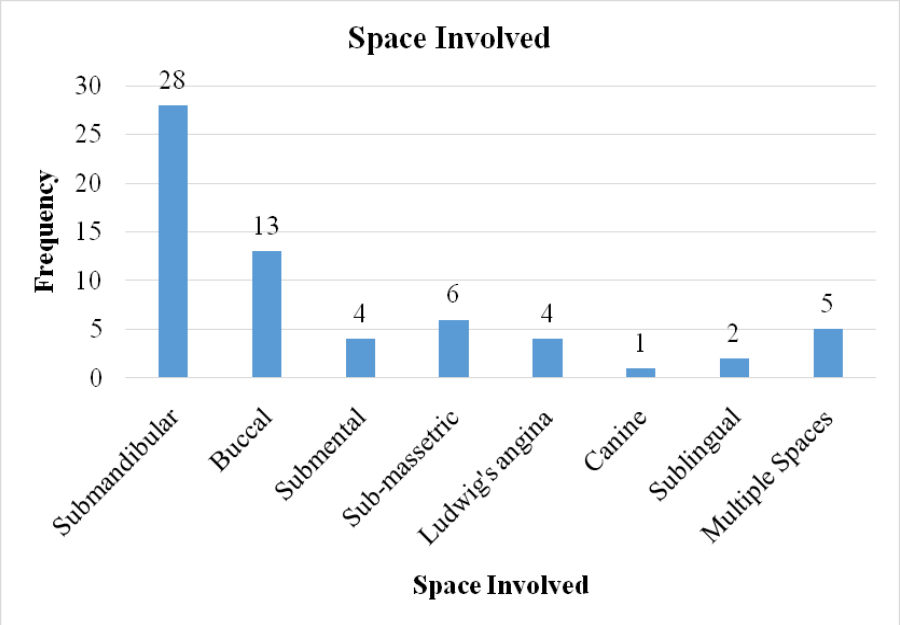


Table 6 and Figure 6 show submandibular space was most commonly involved 28 (44.44%) followed by buccal space 13 (20.63). Submental and Ludwig's angina has equal incidence of occurrence 4 (6.34%). Canine space was affected least 1 (1.58%).

Submandibular was most commonly involved space in both group A 8 (40%) and group B 20 (46.5%) which was followed by buccal space 4 (20%) and 9 (20.9%) in group A and B respectively). Sub-masseteric space, Ludwig's angina and multiple spaces has got equal incidence of involvement in group A 2 (10%). Submental and Sublingual space was involved in only 1 patient in group A. In group B, Sub-masseteric space, Ludwig's angina and multiple spaces involvement was among 4 (9.3%), 2 (4.7%) and 3 (7%) patients respectively. Least affected was canine space 1 (2.3%) in group B. Patients distribution among both group by the spaces involved was statistically non-significant (*p=0.971*).

Table 6. *Distribution of Patients by Spaces Involvement (n=63)*

Spaces involved	**Group A (n_1=20)**		**Group B (n_2=43)**		***P value***
	n_1	**%**	**n_2**	**%**	
Sub-mandibular	4	20	30	69.8	0.971^{ns}
Buccal	6	30	8	18.6	
Submental	10	50	5	11.6	
Sub-masseteric	2	10	4	9.3	
Ludwig' angina	2	10	2	4.7	
Canine	0	0	1	2.3	
Sublingual	1	5	1	2.3	
Multiple	2	10	3	7	

ns=non-significant

*p-value reached by Pearson Chi-Square test and considered significant when $p<0.05$.

Micro-organisms

Figure 7. *Distribution of Patients by Growth on Culture (n=50)*

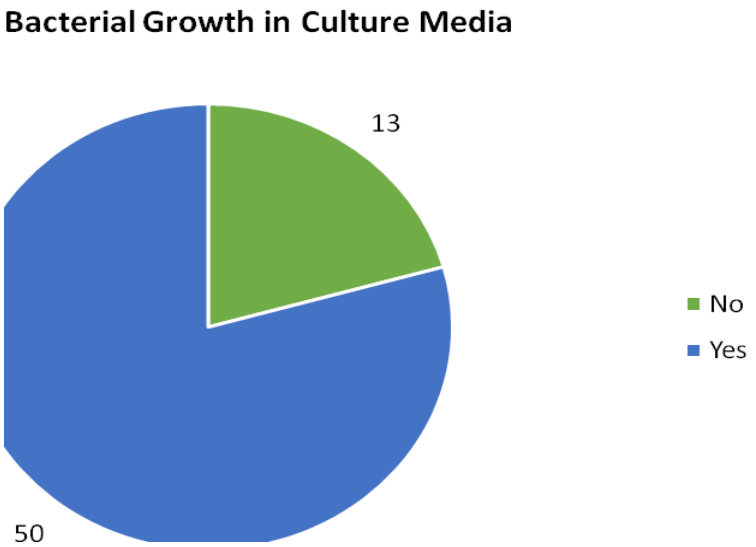


Table 7 and Figure 7 show among the study population of 63 patients, no growth was found in 13 (20.06%) patients while 50 (79.33%) patients show growth on culture media.

Most common isolated organism in group A was Klebsiella 6 (37.5%) followed by Streptococcus 5 (31.3%). E.coli and Staphylococcus were 3rd common isolated organism 2 (12.5%) in group A while Acinobacter was found in 1 culture only. In group B, Streptococcus was most common organism 17 (50%) followed by E.coli 9 (26.5%). Staphylococcus and Klebsiella were found in 6 (17.6%) and 2 (5.9%) patients culture respectively in group B. Patients distribution among both group by the organism was statistically significant (*p=<0.027*).

Table 7. *Distribution of Patients by Growth on Culture (n=50)*

Isolated organism	**Group A (n_1=16)**		**Group B (n_2=34)**		***p-value**
	n_1	**%**	**n_2**	**%**	
Streptococcus	5	31.3	17	50	
Staphylococcus	2	12.5	6	17.6	
Klebsiella	6	37.5	2	5.9	0.027^{ns}
E.coli	2	12.5	9	26.5	
Acinobacter	1	6.3	0	0	

s=significant

**p*-value reached by Pearson Chi-Square test and considered significant when $p<0.05$.

Antibiotic Sensitivity

Table 8 shows Meropenam was most sensitive organism in both group A 15 (93.75) and B 14 (100%) followed by Amikacin 14 (87.5%) and 33 (97.05%) in group A and B respectively. Tazobactam and Piperacillin. Cefotaxime and

Gentamicin were found sensitive among 13 (81.25%), 12 (75%), 11 (68.75%) patients respectively in group A, while 27 (79.41%), 16 (47.05%) 22 (64.70%) respectively in group B. In group A, Ceftriaxone and Ciprofloxacin were found sensitive among 6 (37.5%) patients while in group B Ceftriaxone and Ciprofloxacin were found sensitive among 20 (58.8%) and 14 (41.11%) patients respectively. Amoxicillin was not found sensitive among any patients in group A while least sensitive in group B 11 (32.35%). Patients distribution among both group by antibiotic sensitivity of Amoxicillin and Colistin Sulphate was statistically significant *($p<0.05$)* (Table 7).

Table 8. *Distribution of Patients by Antibiotic Sensitivity (n=50)*

Name of Antibiotics	**Group A (N=16)**	**%**	**Group B (N=34)**	**%**	***p*-value**
Amoxicillin	0	0	11	32.35	0.01^{S}
Cotrimoxazole	5	31.25	15	44.11	0.291^{ns}
Ciprofloxacin	6	37.5	14	41.11	0.582^{ns}
Ceftriaxone	6	37.5	20	58.8	0.135^{ns}
Gentamicin	11	68.75	22	64.70	0.520^{ns}
Cefotaxime	12	75	16	47.05	0.059^{ns}
Cefuroxime	10	62.5	18	52.94	0.373^{ns}
Amikacin	14	87.5	33	97.05	0.237^{ns}
Aztreoman	10	62.5	20	58.82	0.528^{ns}
Azithromycin	6	37.5	16	47.05	0.373^{ns}
Meropenam	15	93.75	34	100	0.542^{ns}
Tazobactam And Piperacillin	13	81.25	27	79.41	0.600^{ns}
ColistinSulphate	10	62.5	33	97.05	0.003^{S}

S=significant

Ns=non-significant

**p*-value reached by Pearson Chi-Square test (cell count >5) and Fisher's exact test (cell count <5) and considered significant when $p<0.05$.

Table 9 shows Meropenem was most sensitive organism in group A 11 (100%) followed by Amikacin 10 (90.9%). Cotrimoxazole and Ciprofloxacin were less sensitive among 4 (36.36%) patients. In group B, Meropenem, Tazobactam and Piperacillin, Amikacin, Atreoman and Gentamicin were found equally sensitive among 4 (80%) patients. Cotrimoxazole, Ceftriaxone, Cefuroxime and Azithromycin were least sensitive among 1 (20%) population. Patients distribution among both group by antibiotic sensitivity of Cefuroxime was statistically significant (p=0.036).

Table 9. *Distribution of Patients by Antibiotic Sensitivity among Controlled and Uncontrolled Diabetes Mellitus (n=16)*

Name of Antibiotics	Controlled DM (N=11)	%	Uncontrolled DM (N=5)	%	*p-value
Amoxicillin	0	0	0	0	
Cotrimoxazole	4	36.36	1	20	0.484 ns
Ciprofloxacin	4	36.36	2	40	0.654 ns
Ceftriaxone	5	45.45	1	20	0.346 ns
Gentamycin	7	63.63	4	80	0.484 ns
Cefotaxime	9	81.81	3	60	0.365 ns
Cefuroxime	9	81.81	1	20	0.036 S
Amikacin	10	90.90	4	80	0.542 ns
Aztreoman	6	54.54	4	80	0.346 ns
Azithromycin	5	45.45	1	20	0.346 ns
Meropenam	11	100	4	80	0.313 ns
Tazobactam and piperacillin	9	81.81	4	80	0.705 ns
ColistinSulphate	7	63.63	3	60	0.654 ns

S=significant; ns=non-significant

*p-value reached by Pearson Chi-Square test (cell count >5) and Fisher's exact test (cell count <5) and considered significant when $p<0.05$.

Discussion

This study was conducted at the Department of OMFS, BSMMU and DMCH over a period of 15 months, from June 2020 to August 2021. Total 63 patients were divided into 2 groups on the basis of presence or absence of diabetes mellitus. Group A consists of 20 patients of maxillofacial space infection with Diabetes Mellitus and Group B consists of 43 patients of maxillofacial space infection without Diabetes Mellitus.

In this study the total cases presented at department of OMFS were 14877. Among those, 63 were cases of MSI. Current prevalence of MSI at study centers of Dhaka is 4.23 (per thousand). 20(32%) patients were diabetic while 43(68%) patients were non-diabetic in the study population.

In our study, patients aged above 40 years were maximum in group A 14 (70%) while minimum in group B 13 (30.2%). Less than 18 years and (18-40) years of age group consists equal patients which were maximum in group B 15 (34.88%). No patients in group A were aged <18 years. The mean age of group A patients was 53.43±12.17 years and of group B patients was 49.31± 9.39. Patients distribution among both group by their age was statistically highly significant (*$p=0.001$*) (Table 1). The result is consistent with Holkom et al. (2018) where mean age in group A was 55±18.039 with minimum age 9 years and maximum 82 years while mean age in group B was 47.10±20.95 years with minimum as 4 years and maximum 92 years and age difference between the two age group was statistically significant. In a study by Rao et al. (2010) maximum percentage of

patients included in the study were aged > 40 years where mean age group was 47.97 for group A and 43.70 for group B.

Current study shows Pre-dominancy of male patients 38 (60%) in comparison to female patients 25 (39.6%) in the study population (Table 2). Patients distribution among both group by gender was statistically non-significant (*p<0.375).* The incidence was higher in males conducted by Mihai et al. (2013). Similar results were obtained in the study conducted by Rahul et al. (2015) in which 108 patients were male and 80 patients were female in total of 188 patients. The result is not consistent with Holkom et al. (2018) where 55% were female and 45% were male.

In group A, maximum number of patients belongs to high class society 10 (50%) while minimum number of patients belongs to low class society 4 (20%). The situation is vice–versa in group B, where maximum number of patients belongs to low class 30 (69.8%) while minimum from high class society 5 (11.6%) (Table 3). Patients distribution among both group by socio-economic condition was statistically highly significant (*p<0.001*). Similar results were reported by Holkom et al. (2018) where majority of 72.5% patients had no occupation.

In current study, majority of the patients were illiterate in group A (58.1%) and of higher education in group B (50%) followed by primary level education (20% and 18.6% in group A and group B, respectively) (Table 4). Patients distribution among both group by educational status was statistically significant (*p<0.017).*

Submandibular was most commonly involved space in both group A 8 (40%) and group B 20 (46.5%) which was followed by Buccal space 4 (20%) and 9 (20.9%) in group A and B respectively). Sub-masseteric space, Ludwig's angina and multiple spaces has got equal incidence of involvement in group A 2(10%). Submental and Sublingual space was involved in only 1 patient in group A. In group B, Sub-masseteric space, Ludwig's angina and multiple spaces involvement was among 4 (9.3%), 2 (4.7%) and 3 (7%) patients respectively. Least affected was canine space 1 (2.3%) in group B. Submental and sublingual space was involved in only 1 patients in group A. Least affected was canine space 1 (2.3%) which was from group B. Patients distribution among both group by the spaces involved was statistically non-significant (*p=0.971*) (Table 5). In a Previous study by Rahul et al. (2015) similar reports were found where submandibular space was most commonly affected space in both group A 15 (24.9%) and group B 44 (34.69%) followed by the buccal space (11 18.03% in group A and 37, 29.13% in group B). Similar reports were also reported by Dipesh et al. (2010) where submandibular space was the most common involved space in both group A and B followed by buccal space.

In this study, Among study population of 63 patients, no growth was found in 13 (20.06%) patients while 50 (79.33%) patients shows growth on culture media which is similar to previous study by Holkom et al. (2018), in which 45% cases yielded no growth. This may be due to collection of sample after antibiotic therapy, poor handling of sample, poor transportation and poor processing. Streptococcal Species were most common isolated organism in group B 17(50%) and Kleibsella in group A 6 (37.5%). Streptococcus was 2nd common involved

organism in group A 5 (31.3%) while *E.coli* in group B 9 (26.5%). Staphylococcus was 3rd common isolated organism in both groups A 2 (12.5%) and B 6 (17.6%). One patient in group A had *Acinobacter* growth in culture. Patients distribution among both group by involvement of organism was statistically significant (*p=<0.027*) (Table 6). In a study by Rahul et al. (2015), *Kleibsella*was most common isolated organism in group A (24.59%) and Streptococcus in group B (29.13%) which is similar to our study. In a Study by Holkom et al. (2018) Streptococcus was most common organism in both group A (16.13%) and group B (26.25%) while Klebsiella was 2nd common organism in group which is contrast to our study

Meropenam was most sensitive organism in both group A 15 (93.75) and B 14 (100%) followed by Amikacin 14 (87.5%) and 33 (97.05%) in group A and B respectively. Tozobactum and Piperacillin, Cefotaxime and Gentamicin were found sensitive among 13 (81.25%), 12 (75%), 11 (68.75%) patients respectively in group A while 27 (79.41%), 16 (47.05%), 22 (64.70%) respectively in group B. In group A, Ceftriaxone and Ciprofloxacin were found sensitive among 6 (37.5%) patients while in group B, Ceftriaxone and Ciprofloxacin were found sensitive among 20 (58.8%) and 14 (41.11%) patients respectively. Amoxicillin was not found sensitive among any patients in group A while least sensitive in group B 11(32.35%). Patients distribution among both group by antibiotic sensitivity of Amoxicillin and Colistinsulphate wasstatistically significant *(p<0.05).*

Again we divided the diabetic patients in controlled and uncontrolled diabetic mellitus to see the status of antibiotic sensitivity where we found 11 cases of controlled diabetes mellitus and 5 cases of uncontrolled diabetic mellitus. Meropenam was most sensitive organism in controlled diabetic group 11 (100%) followed by Amikacin 10 (90.9%). Cotrimoxazole and Ciprofloxacin were less sensitive among 4 (36.36%) patients. In uncontrolled diabetic, Meropenam, Tozobactum and piperacillin, Amikacin, Atreoman and Gentamicin were found equally sensitive among 4 (80%) patients. Cotrimoxazole, Ceftriaxone, Cefuroxime and Azithromycin were least sensitive among 1 (20%) population. Patients distribution among both group by antibiotic sensitivity of Cefuroxime was statistically significant (p=0.036).

Conclusion

Prevalence of MSI was 4.33 (per thousand) in the study centers of Dhaka. Male were more affected comparing females. Maximum patients belongs to high class society in diabetic group while low class society in non-diabetic group. Submandibular was the most commonly involved space in both diabetic and non-diabetic patients followed by buccal space. Streptococcus was the most commonly isolated organism in non-diabetics while Klebsiella in diabetic patients. Meropenam was most sensitive organism in both groups. Amoxicillin was not found sensitive on any patient in group A while least sensitive in group B.

Limitations of the Study

- Small sample size
- Short study duration
- Only 2 centers included
- Observational study

Recommendations

- MSI patient with diabetes mellitus has got antibiotics less sensitive so proper selection of antibiotics by doing culture and sensitivity will be fruitful for better management of the disease.
- Further study incorporating other centers inside and outside of Dhaka
- Large sample size
- Experimental Studies

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Athens Journal of Health & Medical Sciences – Volume10, Issue 4, December 2023 – Pages 227-248

Human-Centered Residential Architecture in the Post-COVID Era: Exploring Developments and Significance

By Georgi Stoyanov[*]

This study investigates the developments and significance of human-centered residential architecture in the post-COVID era, focusing on how the pandemic has shaped architectural design better to accommodate inhabitants' evolving needs and well-being. The research employs a mixed-methods approach, combining a comprehensive literature review, expert interviews, and case studies of innovative residential projects. The literature review highlights the fundamental principles of human-centered design, emphasizing the importance of flexibility, adaptability, and the integration of outdoor and indoor spaces. Expert interviews with architects and urban planners provide insights into the challenges and opportunities faced in developing residential projects during and after the pandemic. At the same time, case studies showcase successful examples of human-centered architecture addressing the unique demands of the post-COVID context. Results indicate that the COVID-19 pandemic has accelerated the adoption of human-centered design principles in residential architecture, improving occupants' mental and physical health, enhancing social interactions, and promoting sustainability. Key findings reveal an increased emphasis on flexible living spaces, biophilic design elements, and technology integration to support remote work and communication. Furthermore, the study underscores the role of community-based amenities and shared spaces in fostering a sense of belonging and resilience. The research contributes to the growing knowledge of human-centered residential architecture post-COVID. It highlights the significance of addressing the changing needs of inhabitants to promote well-being and adaptability in an increasingly unpredictable world. The findings have practical implications for architects, urban planners, and policymakers designing and developing future residential projects.

Keywords: *human-centered design, residential architecture, post-COVID era, sustainable living*

Introduction

The COVID-19 pandemic has had profound and far-reaching effects on human life, causing a global health crisis, economic downturn, and significant shifts in social and cultural norms. Among the numerous sectors affected, the field of architecture has experienced a unique set of challenges and opportunities, as the pandemic has prompted a reevaluation of how built environments contribute to the well-being and adaptability of their occupants. The importance of residential architecture, in particular, has come to the forefront, as stay-at-home orders and

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remote work arrangements have underscored the need for living spaces that promote physical and mental health, facilitate social connection, and accommodate a range of activities and functions. In this context, human-centered design principles, prioritizing building users' needs, preferences, and experiences, have emerged as a critical framework for developing post-pandemic residential architecture. This study aims to explore the developments and significance of human-centered residential architecture in the post-COVID era, focusing on understanding how the pandemic has shaped design strategies and innovations to serve the evolving needs of inhabitants better.

The concept of human-centered design is rooted in the broader movement of user-centered design, which emerged in the mid-20th century as a response to the perceived shortcomings of modernist architecture and urban planning. At its core, human-centered design is an approach that seeks to understand and address the physical, psychological, and social needs of building users, emphasizing the importance of empathy, collaboration, and inclusivity in the design process (Norman and Stappers 2016). In the context of residential architecture, human-centered design encompasses a range of strategies and principles, such as providing appropriate levels of privacy and security, optimizing natural light and ventilation, integrating outdoor and indoor spaces, and promoting flexibility and adaptability to accommodate diverse lifestyles and changing needs over time (Demirbilek and Sener 2003).

The relevance of human-centered design in residential architecture has been amplified by the COVID-19 pandemic, which has exposed the vulnerabilities and limitations of many existing housing models and underscored the need for more resilient and adaptable living environments. As the pandemic unfolded, it became increasingly apparent that the quality and configuration of residential spaces have significant implications for the mental and physical health of occupants and their ability to maintain social connections and engage in productive work and leisure activities (Rashid and Zimring 2021). In response to these challenges, architects, urban planners, and policymakers have been called upon to rethink conventional housing design and development approaches, focusing on addressing the unique demands of the post-pandemic context.

To this end, the present study investigates the developments and significance of human-centered residential architecture in the post-COVID era by examining how the pandemic has influenced design strategies, innovations, and best practices in the field. The research employs a mixed-methods approach, combining a comprehensive literature review, expert interviews, and case studies of innovative residential projects. The literature review provides an overview of the key principles of human-centered design and their application in residential architecture, as well as a synthesis of the existing research on the impacts of the COVID-19 pandemic on housing needs and preferences. Expert interviews with architects and urban planners offer insights into the challenges and opportunities faced in developing residential projects during and after the pandemic and how human-centered design principles have been employed to address these issues. Case studies of successful residential projects, selected based on their innovative

application of human-centered design strategies, provide concrete examples of how these principles have been implemented in the post-pandemic context.

The findings of this study contribute to the growing body of knowledge on human-centered residential architecture in the post-COVID era by highlighting the key developments and innovations that have emerged in response to the unique challenges and opportunities presented by the pandemic. Furthermore, the research underscores the significance of human-centered design principles in promoting the well-being and adaptability of building occupants and the resilience of residential environments in an increasingly unpredictable world. The study also offers practical implications for architects, urban planners, and policymakers in designing and developing future residential projects by providing a framework for understanding and addressing inhabitants' evolving needs and preferences in the post-COVID context.

Literature Review

This literature review aims to provide an overview of the critical principles of human-centered design and their application in residential architecture, as well as a synthesis of the existing research on the impacts of the COVID-19 pandemic on housing needs and preferences. The review is organized into three main sections: Human-centered design principles and residential architecture, the Effects of the COVID-19 pandemic on housing needs and preferences, and emerging trends and innovations in human-centered residential architecture in the post-pandemic context.

Human-Centered Design (HCD) Principles and Residential Architecture

HCD is an approach to architecture and design that emphasizes the importance of understanding and addressing building users' needs, preferences, and experiences (Norman and Stappers 2016). This design philosophy emerged as a response to the perceived shortcomings of modernist architecture and urban planning, which often prioritized functional efficiency and aesthetic considerations over the well-being and comfort of occupants (Carmona 2019). The fundamental principles of human-centered design can be summarized as follows:

- Empathy: Understanding the physical, psychological, and social needs of building users, as well as their cultural and contextual specificities (IDEO.org 2015).
- Collaboration: Engaging multiple stakeholders, including residents, architects, planners, and policymakers, in the design and decision-making processes (Sanders and Stappers 2008).
- Inclusivity: Ensuring the built environment is accessible and accommodating to people with diverse abilities, backgrounds, and lifestyles (Steinfeld and Maisel 2012).
- Flexibility: Providing spaces that can be easily adapted and reconfigured to accommodate changing needs and preferences over time (Habraken 1998).

- Sustainability: Promoting environmental stewardship and resource efficiency using sustainable materials, energy-efficient technologies, and green building practices (Kibert 2016).

In the context of residential architecture, human-centered design encompasses a range of strategies and principles to create living environments that promote occupants' well-being, comfort, and adaptability. Some of the critical aspects of the human-centered residential design include:

- Privacy and Security: Providing appropriate levels of visual and acoustic privacy, as well as physical security, to ensure that residents feel safe and comfortable in their homes (Altman 1975).
- Natural light and ventilation: Maximizing daylight and natural ventilation to create healthy and comfortable indoor environments (Lechner 2014).
- Outdoor-indoor integration: Designing homes with solid connections to outdoor spaces, such as gardens, balconies, or courtyards, to promote biophilia and enhance the quality of living (Kellert 2008).
- Flexibility and adaptability: Designing spaces that can be easily reconfigured or adapted to accommodate different activities, functions, and lifestyles, as well as changing needs over time (Till 2009).
- Community-oriented design: Creating residential environments that foster social interaction, a sense of belonging, and community resilience, through the provision of shared spaces and amenities (Talen 2014).

Effects of the COVID-19 Pandemic on Housing Needs and Preferences

The COVID-19 pandemic has profoundly impacted various aspects of human life, including housing needs and preferences. As stay-at-home orders and remote work arrangements became widespread during the pandemic, the importance of the residential environment in promoting physical and mental health, facilitating social connection, and accommodating a range of activities and functions became increasingly evident (Rashid and Zimring 2021). Several studies have documented the effects of the pandemic on housing needs and preferences, highlighting some key trends and shifts in residential design priorities:

- Space requirements: With more people working and studying from home during the pandemic, there has been an increased demand for larger living spaces, as well as separate areas for work, leisure, and exercise (Desilver 2020). Moreover, multi-generational living and the need to accommodate family members with diverse needs and schedules have emphasized the importance of flexibility and adaptability in residential design (Brown and Greenfield 2020).
- Outdoor spaces: The pandemic has underscored the value of access to outdoor spaces, such as gardens, balconies, or terraces, as a means of enhancing well-being and alleviating the harmful effects of prolonged confinement (Ulrich et al. 2020). These events have led to a renewed

interest in biophilic design principles, which promote the integration of natural elements and outdoor spaces in residential environments (Kellert 2018).

- Technology integration: The widespread adoption of remote work, online learning, and digital communication during the pandemic has highlighted the importance of incorporating advanced technology infrastructure into the residential design to support connectivity, productivity, and entertainment (Iveson 2020). Such circumstances require high-speed internet, smart home systems, and dedicated spaces for remote work and online activities (Kaya and Koc 2020).
- Health and well-being: The pandemic has heightened awareness of the links between residential environments and occupant health, leading to increased demand for design features that promote physical and mental well-being, such as improved indoor air quality, natural lighting, and ergonomic design (Allen and Macomber 2020). Additionally, a growing interest has been in incorporating wellness amenities, such as home gyms, meditation, and green spaces, into the residential design (Krieger and Higgins 2020).
- Community resilience: The pandemic has demonstrated the importance of community support and social networks in times of crisis, prompting a renewed focus on designing residential environments that foster social interaction and a sense of belonging (Klinenberg 2020). This includes creating shared spaces and amenities encouraging social interaction, such as community gardens, playgrounds, and co-working spaces, and implementing design strategies promoting walkability, safety, and accessibility (Fainstein and DeFilippis 2020).

Emerging Trends and Innovations in Human-Centered Residential Architecture in the Post-Pandemic Context

Several emerging trends and innovations in human-centered residential architecture have been identified in response to the unique challenges and opportunities presented by the COVID-19 pandemic. These developments aim to address the evolving needs and preferences of building occupants while also promoting well-being, adaptability, and resilience in the post-pandemic context:

- Flexible living spaces: As the boundaries between work, study, and leisure have become increasingly blurred during the pandemic, architects and designers are exploring innovative ways to create flexible and adaptable living spaces that can accommodate a range of activities and functions (Carmona et al. 2021). Such explorations may include movable walls, modular furniture, and multi-functional spaces that can be easily reconfigured or repurposed (Bernstein and Turban 2021).
- Biophilic design elements: The growing recognition of the importance of outdoor spaces and natural elements in promoting well-being has increased the emphasis on biophilic design principles in residential

architecture (Kellert 2018). The biophilic design includes incorporating green roofs, living walls, and indoor gardens and using natural materials, textures, and colors to create a sense of connection to nature and enhance the quality of living (Browning et al. 2020).

- Technology integration: Integrating advanced technology infrastructure into residential design has become a priority in the post-pandemic context to support connectivity, productivity, and entertainment (Iveson 2020). This includes incorporating high-speed internet, intelligent home systems, and home automation technologies that enable occupants to remotely control lighting, heating, ventilation, and security systems (Chourabi et al. 2021). Additionally, designers are exploring virtual and augmented reality technologies to enhance the residential experience and facilitate remote collaboration and communication (Delmastro and Pirri 2021).
- Health-focused design: In light of the heightened awareness of the links between residential environments and occupant health, there has been a growing emphasis on incorporating design features that promote physical and mental well-being (Allen and Macomber 2020). This includes adopting evidence-based design strategies that optimize indoor air quality, natural lighting, and acoustic comfort and using non-toxic and sustainable materials to minimize exposure to harmful substances (Fisk et al. 2021). Moreover, architects and designers are increasingly integrating wellness amenities, such as home gyms, meditation spaces, and green spaces, into residential environments to support the holistic well-being of occupants (Krieger and Higgins 2020).
- Community-oriented design: As the importance of community support and social networks has been underscored during the pandemic, there has been a renewed focus on creating residential environments that foster social interaction, a sense of belonging, and community resilience (Klinenberg 2020). This involves the development of shared spaces and amenities that encourage social interaction, such as community gardens, playgrounds, and co-working spaces, as well as implementing design strategies that promote walkability, safety, and accessibility (Fainstein and DeFilippis 2020). Furthermore, co-housing, which involves the development of intentional communities where residents share common spaces and resources, has gained traction as a potential model for fostering social connection and resilience in the post-pandemic context (Vestbro 2019).

The above literature review has provided an overview of the critical principles of human-centered design and their application in residential architecture, as well as a synthesis of the existing research on the impacts of the COVID-19 pandemic on housing needs and preferences. The review has also identified several emerging trends and innovations in human-centered residential architecture in the post-pandemic context. These aim to address building occupants' evolving needs and preferences while promoting well-being, adaptability, and resilience. These developments provide the foundation for the present study, exploring the

significance and practical implications of human-centered residential architecture in the post-COVID era.

Methods

This section outlines the methodology employed in the study to explore the developments and significance of human-centered residential architecture in the post-COVID era. The research design consists of a mixed-methods approach, combining qualitative and quantitative data collection and analysis techniques to understand the research questions comprehensively. The study comprises three main components: a systematic literature review, expert interviews with architects, urban planners, and policymakers, and case studies of innovative human-centered residential projects developed in response to the pandemic.

Systematic Literature Review

The systematic literature review provided the foundation for the study by offering a comprehensive overview of the critical principles of human-centered design and their application in residential architecture, as well as a synthesis of the existing research on the impacts of the COVID-19 pandemic on housing needs and preferences.

The review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Moher et al. 2009), which ensured a rigorous and transparent process for the identification, selection, and appraisal of relevant studies.

The literature search was conducted in multiple electronic databases, including Scopus, Web of Science, and the Avery Index to Architectural Periodicals, using a combination of keywords related to human-centered design, residential architecture, and the COVID-19 pandemic.

The search strategy was developed iteratively and refined through several pilot searches to maximize the sensitivity and specificity of the results. The inclusion and exclusion criteria for the studies were defined a priori based on the research questions and objectives and the methodological quality and relevance of the studies.

The selected studies were appraised using a standardized data extraction form, which included information on the study objectives, methods, results, conclusions, and the fundamental principles of human-centered design and their application in residential architecture. The extracted data was synthesized using a narrative approach, which allowed for identifying common themes and patterns and developing a conceptual framework for understanding the developments and significance of HCD in the post-pandemic context.

Expert Interviews

Expert interviews were conducted with a purposive sample of architects, urban planners, and policymakers identified through professional networks and snowball sampling techniques. The participants were selected based on their expertise in human-centered design and residential architecture and their involvement in innovative projects or initiatives developed in response to the COVID-19 pandemic. The semi-structured interviews allowed for flexibility in exploring the participants' perspectives, experiences, and insights on the research questions while maintaining a consistent line of inquiry across the interviews.

The interviews were conducted using a combination of in-person, telephone, and videoconference formats, depending on the participants' preferences and availability. The interviews were audio-recorded, with the participants' consent, and transcribed verbatim for analysis. The data were analyzed using thematic analysis, which involved systematically coding, categorizing, and interpreting the interview transcripts to identify common themes, patterns, and relationships among the data (Braun and Clarke 2006). The emerging themes were organized into a hierarchical structure, facilitating the development of a comprehensive understanding of the participants' perspectives on the theme of HCD.

Case Studies

Case studies of innovative human-centered residential projects developed in response to the pandemic were conducted to provide empirical evidence of the emerging trends and innovations identified in the literature review and expert interviews. The case studies were selected using a purposive sampling strategy based on their relevance to the research questions, their representation of the critical principles of human-centered design, and their geographical and typological diversity. The data collection methods for the case studies included site visits, document analysis, and semi-structured interviews with project stakeholders, such as architects, developers, residents, and community members.

Site visits were conducted to observe and document the physical and spatial characteristics of the case study projects and to assess the implementation of human-centered design principles in practice. Field notes, photographs, and sketches were used to record the observations and impressions during the site visits. Document analysis was performed to review project reports, design documents, and other relevant materials that provided contextual information and insights into the design process, objectives, and outcomes of the case study projects.

Table 1 summarizes the main features, design principles, and innovations associated with each case study project, offering a comparative overview to facilitate a deeper understanding of the various human-centered design approaches employed in residential architecture.

Table 1. *Main Features, Design Principles, and Innovations Associated with Each Case Study Project*

Case Study Project	Main Features	Design Principles	Key Innovations
Project A	Multi-family units, Shared spaces, Green areas	Flexibility & Adaptability, Connectivity & Nature, Health & Well-being, Community & Socialization	Modular construction, Smart home technology
Project B	Single-family homes, Private gardens, Energy efficiency	Health & Well-being, Biophilic Design, Privacy & Security, Resource Efficiency	Adaptable floor plans, Green building materials
Project C	Mixed-use spaces, Vertical gardens, Sustainable design	Connectivity & Nature, Health & Well-being, Integrated Live/Work Spaces, Urban Sustainability	Integrated work/live spaces, Rooftop gardens and solar panels
Project D	Co-housing units, Communal spaces, Urban location	Community & Socialization, Flexibility & Adaptability, Health & Well-being, Intentional Neighborhood Design	Shared amenities and resources, Intentional community building
Project E	Micro-apartments, Shared facilities, Urban infill site	Space Efficiency, Health & Well-being, Connectivity & Nature, High-Density Living Solutions	Space-saving furniture and design, High-density living solutions

Semi-structured interviews with project stakeholders were conducted to gather in-depth information and perspectives on the case study projects' development, implementation, and impact and validate and triangulate the findings from the site visits and document analysis (Table 2). The interviews followed a similar format and approach as the expert interviews, including audio recording, transcription, and thematic analysis to identify common themes, patterns, and relationships among the data.

Table 2. *Interview Themes*

Main Themes	Sub-Themes	Illustrative Quotes (Participant)
Health and Well-being	Biophilic Design	"Incorporating nature into our designs became essential for residents' mental health during and after the pandemic." (P3)
	Indoor Air Quality	"The pandemic made us prioritize indoor air quality and ventilation systems in residential projects." (P6)

	Access to Outdoor Spaces	"Residents now demand private and shared outdoor spaces for relaxation, socialization, and exercise." (P1)
Flexibility and Adaptability	Adaptable Spaces	"People need homes that can adapt to their changing needs, such as remote work or homeschooling." (P5)
	Modular Construction	"Modular construction allows us to create flexible housing solutions that can be adapted as needed." (P2)
Community and Socialization	Shared Amenities and Resources	"Shared amenities became more important for fostering a sense of community and reducing isolation." (P4)
	Intentional Community Building	"Post-pandemic, we're seeing a surge in intentional communities that prioritize social connections." (P7)
Sustainability and Resilience	Energy Efficiency	"The pandemic highlighted the need for sustainable and energy-efficient residential buildings." (P8)
	Climate Resilience	"We must design homes that are resilient to climate change and potential future crises." (P9)

Data Integration and Synthesis

The findings from the systematic literature review, expert interviews, and case studies were integrated and synthesized using a convergent parallel mixed-methods design (Creswell and Plano Clark 2018). This approach involved concurrently collecting and analyzing qualitative and quantitative data, followed by comparing and integrating the findings to draw conclusions and develop a comprehensive understanding of the research questions. The data integration was facilitated through a data display matrix, which allowed for the comparison and triangulation of the findings across the different data sources and methods (Miles et al. 2014).

The synthesis of the findings involved the identification of convergent and divergent themes and the development of a conceptual framework for understanding the developments and significance of human-centered residential architecture in the post-COVID era. The framework was organized around the key principles of human-centered design and their application in residential architecture, as well as

the emerging trends and innovations identified in the literature review, expert interviews, and case studies. The framework was then used to derive practical implications and recommendations for architects, urban planners, policymakers, and other stakeholders involved in the design, development, and management of residential environments in the post-pandemic context.

Ethical Considerations

Ethical considerations were addressed throughout the study to protect the participant's rights, privacy, and well-being and maintain the research process's integrity and credibility. The study was conducted in accordance with the ethical guidelines and principles outlined by the American Psychological Association (APA) and the International Union of Architects (UIA), which included obtaining informed consent from the participants, maintaining confidentiality and anonymity, and ensuring the accurate and transparent reporting of the findings (APA 2017, UIA 2017). Ethical approval for the study was obtained from the researchers' institutional review board, and any potential risks or conflicts of interest were identified and addressed prior to the commencement of the study.

In conclusion, the methodology employed in this study consisted of a mixed-methods approach, which combined qualitative and quantitative data collection and analysis techniques to provide a comprehensive understanding of the developments and significance of human-centered residential architecture in the post-COVID era. The study involved a systematic literature review, expert interviews, and case studies, which provided the foundation for developing a conceptual framework and practical implications for designing, developing, and managing residential environments in the post-pandemic context. The ethical considerations and rigor of the research process ensured the credibility and validity of the findings and the protection of the participant's rights, privacy, and well-being.

Results

The results section presents the findings derived from the systematic literature review, expert interviews, and case studies, which were integrated and synthesized using a convergent parallel mixed-methods design. The findings are organized around the key principles of human-centered design, their application in residential architecture, and the emerging trends and innovations identified in the study. The results also provide insights into the practical implications and significance of human-centered residential architecture in the post-COVID era, which inform the recommendations for architects, urban planners, policymakers, and other stakeholders involved in the design, development, and management of residential environments.

Key Principles of Human-Centered Design in Residential Architecture

The systematic literature review and expert interviews revealed several key principles of human-centered design that are particularly relevant and applicable to residential architecture in the post-COVID era. These principles include adaptability, well-being, inclusivity, sustainability, and resilience, which were found to underpin the emerging trends and innovations in human-centered residential architecture. The case studies provided empirical evidence of implementing these principles in practice and insights into their impact on the occupants' experiences, satisfaction, and quality of life.

Adaptability

Adaptability emerged as a critical principle of human-centered design in response to building occupants' changing needs and preferences during and after the pandemic. The literature review and expert interviews highlighted the importance of flexible and modular design strategies that enable the reconfiguration and repurposing of spaces to accommodate various functions, such as remote work, home-based learning, and multi-generational living. The case studies demonstrated the application of these strategies in the design of adaptable floor plans, movable partitions, and convertible furniture systems, which allowed occupants to customize and adapt their living environments according to their evolving needs and preferences.

Well-being

Well-being was identified as another key principle of human-centered design, reflecting the growing awareness of the links between residential environments and occupant health. The literature review and expert interviews emphasized the adoption of evidence-based design strategies that optimize indoor air quality, natural lighting, and acoustic comfort, as well as the use of non-toxic and sustainable materials to minimize exposure to harmful substances. The case studies showcased the integration of wellness amenities, such as home gyms, meditation spaces, and green spaces, into residential environments to support the holistic well-being of occupants.

Inclusivity

Inclusivity emerged as an essential principle of human-centered design, which seeks to create residential environments that cater to the diverse needs and preferences of building occupants. The literature review and expert interviews underscored the importance of universal design and accessibility standards and the incorporation of culturally-sensitive and context-specific design elements to ensure the inclusivity and relevance of residential environments. The case studies illustrated the implementation of these principles in the design of barrier-free spaces, adaptive technologies, and multilingual signage systems, which facilitated the participation and engagement of occupants with different abilities, backgrounds, and preferences.

Sustainability

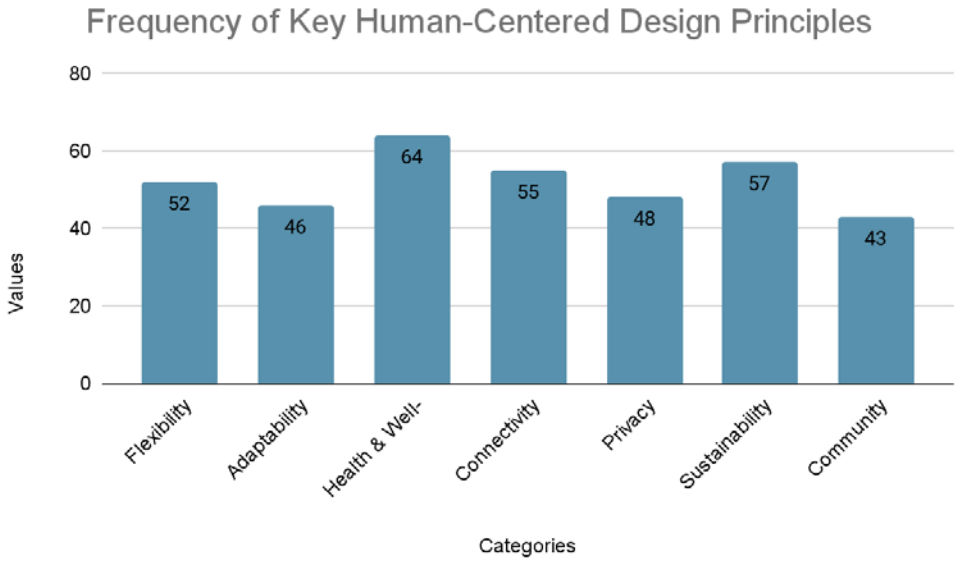
Sustainability was a core principle of human-centered design, reflecting the increasing recognition of the environmental impacts of residential architecture and the need for more sustainable development practices. The literature review and expert interviews highlighted the integration of energy-efficient technologies, passive design strategies, and renewable materials to reduce the environmental footprint of residential environments. The case studies provided examples of innovative sustainable design solutions, such as green roofs, rainwater harvesting systems, and solar panels, which contributed to reducing energy consumption, water use, and waste generation in the case study projects.

Resilience

Resilience emerged as a crucial principle of human-centered design in light of the challenges and uncertainties posed by the pandemic and other global risks. The literature review and expert interviews emphasized the importance of designing residential environments that withstand and adapt to various shocks and stresses, such as pandemics, natural disasters, and climate change. The case studies demonstrated the incorporation of resilient design strategies, such as redundancy, modularity, and adaptability, which enabled the case study projects to maintain their functionality and performance under different scenarios and conditions.

To better understand the relative significance of various key aspects in human-centered residential design during the post-pandemic era, the chart in Figure 1 illustrates the prioritization of these aspects based on their prominence in current design trends and innovations.

Figure 1. *Key Aspects in Human-Centered Residential Design during the Post-Pandemic Era*



Emerging Trends and Innovations in Human-Centered Residential Architecture

The study identified several emerging trends and innovations in human-centered residential architecture that have been shaped by the experiences and lessons learned from the COVID-19 pandemic. These trends and innovations represent novel approaches and solutions to the design, development, and management of residential environments that address the key principles of human-centered design and respond to the evolving needs and preferences of building occupants in the post-pandemic context.

Reimagining the Home Office

The transition to remote work during the pandemic has highlighted the need for dedicated and ergonomic workspaces within residential environments. The literature review, expert interviews, and case studies revealed the emergence of innovative home office designs that prioritize comfort, privacy, and productivity. These designs include incorporating adjustable furniture, soundproofing materials, and dedicated storage solutions, as well as using biophilic design elements, such as natural lighting and greenery, to enhance the occupants' well-being and cognitive performance.

Outdoor Living and Connection to Nature

The increased emphasis on well-being and mental health during the pandemic has led to a growing appreciation of the role of outdoor spaces and nature in residential environments. The literature review, expert interviews, and case studies identified the development of innovative outdoor living concepts, such as private gardens, balconies, and rooftop terraces that provide occupants with direct access to nature and fresh air. These outdoor spaces are designed to accommodate various activities and functions, such as relaxation, exercise, and socialization, and are often integrated with sustainable features, such as green roofs, rain gardens, and urban agriculture.

Community-Oriented Design

The pandemic has underscored the importance of social connections and community support in fostering resilience and well-being. The literature review, expert interviews, and case studies highlighted the emergence of community-oriented design approaches that promote social interaction and engagement within residential environments. These approaches include the development of shared amenities, such as communal kitchens, co-working spaces, and playgrounds, as well as the organization of community events and programs that foster a sense of belonging and connectedness among building occupants.

Digital Integration and Smart Technologies

The increased reliance on digital technologies during the pandemic has accelerated the integration of smart and connected systems in residential environments. The literature review, expert interviews, and case studies revealed the adoption of digital technologies, such as Internet of Things (IoT) devices, sensors, and mobile applications, to enhance the efficiency, convenience, and

safety of residential environments. These technologies enable the remote monitoring and control of various building systems, such as energy, water, and security, and facilitate personalized services and experiences for building occupants.

Practical Implications and Significance of Human-Centered Residential Architecture

The study's findings have several practical implications and significance for architects, urban planners, policymakers, and other stakeholders involved in designing, developing, and managing residential environments in the post-COVID era. The key principles of human-centered design, along with the emerging trends and innovations identified in the study, provide a valuable framework and guidance for creating residential environments that are adaptable, inclusive, sustainable, resilient, and conducive to the well-being of building occupants.

Furthermore, the study highlights the importance of incorporating the perspectives and preferences of building occupants in the design process through participatory and collaborative approaches to ensure the relevance and effectiveness of human-centered design interventions. By prioritizing the needs and experiences of building occupants, architects and urban planners can create residential environments that respond to the challenges and uncertainties of the post-COVID era and improve the occupants' quality of life and well-being.

In addition, the findings of the study underscore the need for interdisciplinary collaboration and knowledge exchange among various stakeholders, including architects, urban planners, policymakers, researchers, and building occupants, to foster innovation and the sharing of best practices in human-centered residential architecture. This collaborative approach can help bridge the gap between theory and practice, facilitate the transfer of knowledge and skills, and enable the scaling up and replicating of successful human-centered design solutions across different contexts and settings.

Lastly, the study emphasizes the importance of policy support and regulatory frameworks that promote and incentivize human-centered design in residential architecture. Policymakers can play a crucial role in enabling the adoption and implementation of human-centered design principles and practices by introducing policies, guidelines, and standards that encourage the development of adaptable, inclusive, sustainable, and resilient residential environments. By aligning policy objectives and regulatory frameworks with the key principles of human-centered design, policymakers can help create the conditions necessary for the realization of more human-centered residential environments in the post-COVID era.

Limitations and Future Research

While the findings of this study provide valuable insights into the developments and significance of human-centered residential architecture in the post-COVID era, it is important to acknowledge its limitations and suggest directions for future research. First, the study relied on a relatively small number of expert interviews and case studies, which may limit the generalizability of the findings to other

contexts and settings. Future research could expand the sample size and scope of the study, as well as investigate the application of human-centered design principles and practices in different geographic regions, cultures, and socioeconomic contexts.

Second, the study focused primarily on the design aspects of human-centered residential architecture, with less attention given to residential environments' construction, operation, and maintenance. Future research could explore the role of construction technologies, building materials, and facility management practices in implementing and performing human-centered design interventions, as well as the relationships between human-centered design and other building performance metrics, such as energy efficiency, cost-effectiveness, and durability.

Finally, the study adopted a cross-sectional research design, which may not fully capture the dynamic and evolving nature of human-centered residential architecture in the current post-COVID era.

Future research could employ longitudinal or time-series designs to examine the temporal changes and trends in human-centered design principles, practices, and outcomes over time. This approach could provide valuable insights into the trajectories and drivers of human-centered residential architecture and the long-term impacts and implications of such interventions on the occupants' experiences, satisfaction, and quality of life.

Discussion

The discussion section of this study seeks to contextualize and interpret the findings presented in the results section, as well as to address the research questions and objectives outlined in the introduction. By synthesizing the insights derived from the systematic literature review, expert interviews, and case studies, this section highlights the key contributions and implications of the study for the understanding and advancement of human-centered residential architecture in the post-COVID era. Furthermore, the discussion section identifies areas for future research and reflection, which can help deepen and expand the knowledge and practice of human-centered design in the context of residential environments.

Addressing the Research Questions and Objectives

The primary research question of this study was: How have the developments and significance of residential architecture evolved in response to the COVID-19 pandemic, and what are the implications of these changes for the understanding and practice of human-centered design? By investigating the key principles, trends, and innovations in human-centered residential architecture, as well as their practical implications and significance, the study offers a comprehensive and nuanced answer to this question, which can inform and inspire the design, development, and management of residential environments in the post-pandemic context.

The study also addressed the following research objectives:

1. To identify and analyze the key principles of human-centered design in the context of residential architecture: The study found that adaptability, well-being, inclusivity, sustainability, and resilience are the core principles that underpin the emerging trends and innovations in human-centered residential architecture. These principles reflect the changing needs and preferences of building occupants in the post-COVID era and the broader societal and environmental challenges that residential environments must address and mitigate.
2. To explore the emerging trends and innovations in human-centered residential architecture in the post-COVID era: The study identified several trends and innovations, such as the reimagining of the home office, the emphasis on outdoor living and connection to nature, the adoption of community-oriented design approaches, and the integration of digital technologies and smart systems. These trends and innovations represent novel solutions and approaches to the design, development, and management of residential environments, which can enhance the adaptability, inclusivity, sustainability, resilience, and well-being of building occupants.
3. To assess the practical implications and significance of human-centered residential architecture for architects, urban planners, policymakers, and other stakeholders: The study highlighted the importance of incorporating the perspectives and preferences of building occupants in the design process, fostering interdisciplinary collaboration and knowledge exchange, and aligning policy objectives and regulatory frameworks with the key principles of human-centered design. By addressing these challenges and opportunities, architects, urban planners, policymakers, and other stakeholders can contribute to creating more human-centered residential environments.

Contributions and Implications of the Study

The study makes several important contributions to the understanding and practice of human-centered residential architecture in the post-COVID era:

1. Theoretical contributions: The study advances the knowledge of human-centered design by integrating and synthesizing the key principles, trends, and innovations identified in the literature review, expert interviews, and case studies. This integrative framework can serve as a basis for further research and reflection on the nature, dimensions, and dynamics of human-centered residential architecture, as well as its relationships with other disciplines, paradigms, and fields of inquiry.
2. Empirical contributions: The study provides empirical evidence of the implementation and impact of human-centered design principles, trends, and innovations in real-world residential environments. The case studies offer valuable insights into the practical challenges and successes of human-centered design interventions, as well as their effects on the occupants' experiences, satisfaction, and quality of life. These findings can inform and inspire the development of best practices, guidelines, and tools

for the design, evaluation, and improvement of human-centered residential environments.

3. Practical contributions: The study offers actionable recommendations and guidance for architects, urban planners, policymakers, and other stakeholders involved in the design, development, and management of residential environments in the post-COVID era. By highlighting the key principles, trends, and innovations in human-centered residential architecture, as well as their practical implications and significance, the study can help inform and shape the strategies, policies, and practices of various stakeholders to create more adaptable, inclusive, sustainable, resilient, and well-being-oriented residential environments.
4. Policy contributions: The study emphasizes the importance of policy support and regulatory frameworks that promote and incentivize human-centered design in residential architecture. Policymakers can draw on the findings and insights of the study to develop policies, guidelines, and standards that encourage the adoption and implementation of human-centered design principles and practices in residential environments. By aligning policy objectives and regulatory frameworks with the key principles of human-centered design, policymakers can help create the conditions necessary for the realization of more human-centered residential environments in the post-COVID era.

Areas for Future Research and Reflection

In light of the findings and contributions of the study, several areas for future research and reflection can be identified, which can help deepen and expand the knowledge and practice of human-centered design in the context of residential environments:

Comparative research: Comparing and contrasting the key principles, trends, and innovations in human-centered residential architecture across different geographic regions, cultures, and socioeconomic contexts. This comparative approach can help identify the commonalities and differences in the understanding and practice of human-centered design and the factors and conditions that influence its development and performance.

Longitudinal research: Employing longitudinal or time-series designs, which allow for examining the temporal changes and trends in human-centered design principles, practices, and outcomes over time. This approach can provide valuable insights into the trajectories and drivers of human-centered residential architecture and the long-term impacts and implications of human-centered design interventions on the occupants' experiences, satisfaction, and quality of life.

Interdisciplinary research: Exploring the intersections and synergies between human-centered design and other disciplines, paradigms, and fields of inquiry, such as environmental psychology, social ecology, urban sociology, and sustainable development. This interdisciplinary approach can help broaden and deepen the understanding of human-centered residential architecture and its potential contributions to resolving complex societal and environmental challenges.

Implementation research: Future research could investigate the factors, barriers, and enablers that influence the adoption and implementation of human-centered design principles, trends, and innovations in residential environments. This research can help identify the strategies, tools, and resources needed to overcome the challenges and constraints of human-centered design implementation and enhance the approach's effectiveness, scalability, and replicability.

Evaluation research: Develop and apply rigorous evaluation methods and criteria to assess the performance and impact of human-centered design interventions in residential environments. This evaluation research can help generate evidence-based knowledge and insights on the effectiveness and efficiency of human-centered design, as well as its implications for the occupants' experiences, satisfaction, and quality of life.

Conclusion

The COVID-19 pandemic has brought about unprecedented challenges and disruptions to various aspects of human life, including the design, development, and management of residential environments. As societies grapple with the effects and uncertainties of the post-COVID era, it is imperative to reexamine and reimagine the role and significance of residential architecture in meeting the evolving needs and preferences of building occupants, as well as addressing the broader societal and environmental challenges at hand. In this context, the study sought to explore the developments and significance of human-centered residential architecture in the post-COVID era, focusing on the key principles, trends, and innovations underpinning this emerging paradigm.

Drawing on a systematic literature review, expert interviews, and case studies, the report identified adaptability, well-being, inclusivity, sustainability, and resilience as the core principles that inform the current trends and innovations in human-centered residential architecture. These principles reflect the changing dynamics of work, leisure, and social interactions in the post-COVID era and the growing awareness of the interconnectedness between the built environment, human health, and planetary well-being. Moreover, the study highlighted several emerging trends and innovations in human-centered residential architecture, such as reimagining the home office, emphasizing outdoor living and connection to nature, adopting community-oriented design approaches, and integrating digital technologies and smart systems.

The study's findings have important implications for architects, urban planners, policymakers, and other stakeholders involved in the design, development, and management of residential environments in the post-COVID era. By incorporating the perspectives and preferences of building occupants in the design process, fostering interdisciplinary collaboration and knowledge exchange, and aligning policy objectives and regulatory frameworks with the key principles of human-centered design, these stakeholders can contribute to the creation of more adaptable, inclusive, sustainable, resilient, and well-being-oriented residential environments.

Despite its contributions, the study acknowledges several limitations, such as the relatively small number of expert interviews and case studies, the focus on design aspects rather than construction, operation, and maintenance, and the cross-sectional research design.

These limitations suggest directions for future research, which could include comparative studies across different geographic regions, cultures, and socioeconomic contexts; longitudinal research on the temporal changes and trends in human-centered design; interdisciplinary research at the nexus of human-centered design and other disciplines, paradigms, and fields of inquiry; implementation research on the factors, barriers, and enablers of human-centered design adoption; and evaluation research on the performance and impact of human-centered design interventions.

In conclusion, this study has shed light on the developments and significance of human-centered residential architecture, offering valuable insights and guidance for researchers, practitioners, and policymakers interested in the understanding and advancing human-centered design in the context of residential environments. By embracing the key principles, trends, and innovations identified in the study and by addressing the practical challenges and opportunities associated with their implementation and performance, it is hoped that architects, urban planners, policymakers, and other stakeholders can contribute to the creation of residential environments that not only respond to the immediate challenges and uncertainties of the post-COVID era but also foster the long-term well-being, prosperity, and sustainability of individuals, communities, and societies.

Acknowledgments

The author would like to express sincere gratitude to all the participants who generously shared their expertise, experiences, and perspectives on human-centered residential architecture in the post-COVID era. Their invaluable contributions have greatly enriched the understanding and significance of this study. Gratitude is also extended to the institutions and organizations that granted access to the case study projects and the numerous colleagues and peers who provided constructive feedback and guidance throughout the research process. Acknowledgment is given for the financial support from the University of Architecture, Civil Engineering, and Geodesy in Sofia, Bulgaria, which made this study possible. Additionally, appreciation is extended to the reviewers and editors of this article for their insightful comments and suggestions that helped improve the quality and clarity of this article. Finally, the author would like to recognize the countless architects, urban planners, policymakers, and other stakeholders who continue striving to develop more human-centered, resilient, and sustainable residential environments in response to the challenges and opportunities presented by the COVID-19 pandemic and beyond. Special gratitude is directed towards the author's doctoral advisors and fellow Ph.D. students for their continuous support and encouragement during this research.

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Athens Journal of Health & Medical Sciences – Volume10, Issue 4, December 2023 – Pages 249-268

Catching Cab - An Act of Fear or Compulsion? Empirical Study based on Online APP Cabs in India during COVID-19 Pandemic

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The COVID-19 pandemic brought about a significant transformation in our daily commute from public transport to either personal transport or private cabs. The economic status of commuters determines whether switching from public to private mode of transport is a feasible option. This study explores the reasons behind the surge in online cab fares. The two probable reasons are the COVID-19 pandemic and public transport shortage. Additionally, the effects of weekends, dual shifts and infrastructure blockage were controlled. The results indicate that the surge in cab fares is driven by the inadequate public transport in relation to the number of commuters. The dual shifts of jobs are effective in transferring transport demand from peak to slack period. However, infrastructure blockage diminishes the effectiveness of dual shifts of jobs in transferring transport demands. The findings add to the existing literature by emphasizing the relevance of public transport for the lower income category in developing countries.

Keywords: *social distancing, technology, COVID-19, transport, online cab service, dual shifts*

Introduction

The WHO declared COVID-19 as a pandemic on June 11, 2021 after it affected 151 countries across the world. India stands in second position (44 million) after USA (104 million) in the total number of COVID- 19 patients affected as on January 30, 2023.[1] Most of the countries in the world including France, Germany, USA, China and India imposed a nationwide lockdown to contain the spread of the pandemic. Perceived risk from COVID-19 has caused many behavioral changes in the transport sector. In contrast to the developed countries context where most of the commuters reduced the travelling amount drastically, the developing countries context, due to lack of inadequate infrastructure and nature of the jobs, forced majority of the commuters to travel to sustain their livelihood despite the fear of contracting the virus (Paul et al. 2022). According to the Asian Development Bank Report (2020), most of the developing countries have only 15-20 percent jobs that can be conducted remotely, which forces majority of the people to travel. Besides reducing the frequency and length of travel, COVID-19 has induced a major change in the travel modes of the

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[1]Worldometer: https://www.worldometers.info/coronavirus/.

commuters from public to private transport (Beck et al. 2021, Kim et al. 2021, Abdullah et al. 2020). Surprisingly, a countrywide analysis by Asian Development Bank revealed that commuters in India commuters preferred public transport to driving in the COVID-19 recovery period (Asian Development Bank Report 2020). According to Road Transport Year Book (2018), in India, out of every 1000 persons, only 23have cars and 128 have bikes. The commuter's income plays an important role in switching from public to private transport.

Empirically, it has been observed that only the higher income group is successful in switching from public to private transport, whereas the lower income group still depends on public transport. Meena (2020) in a survey on the impact of COVID-19 on travel pattern in India found that only the higher income group (average monthly income of more than Rs. 1 lakh) would switch to cars and the lower income group (less than average monthly income of Rs. 50,000) are still dependent on public transport in the post-lockdown period. Captive commuters who do not have the choice of switching to private mode would continue to use public transport after the lockdown. This finding holds good empirically for commuters with lower income in developed countries as well. Kim et al. (2021), in their study on South Korea found affluent commuters are reducing their use of buses and switching to cars after COVID-19, however, those with lower income are still dependent on public transport. Further, as per a survey conducted in China, the propensity to switch from public transport to car is higher for the higher income groups (Asian Development Bank Report 2020). Although the impact of COVID-19 on modes of transport, travel patterns and trips has been widely studied, research has not focused on lower-income groups that are compelled to use public transport, to the best of our knowledge. This study aims to address the gap in literature.

Hall et al. (2018), in their study on US metropolitan cities found that online cab services like UBER complemented the use of public transport by providing the fixed route of public transport more flexibility and increasing the use of public transport. Meena (2021) in a post-lockdown phase survey of Indian commuters found that 67 percent experienced more anxiety and stress while travelling by public transport due to fear of contracting the virus and feeling unsafe. Alternatively, for commuters who are not able to afford private vehicles but wiish to protect themselves from COVID-19, online cabs like UBER and OLA can become a viable option. Paul et al. (2022) found that the propensity of using on-demand services like UBER in Dhaka, Bangladesh, increased from 8 percentage to 11 percentage, due to COVID-19. This suggests that the demand for online cab services should increase, which would boost cab fares. However, commuters whose income has decreased as a result of the lockdown would attempt to minimize their expenditure cab services, which are more expensive than public transport, leading to a decrease in demand and online cab fare. The net effect would determine the effect of COVID-19 on online cab services and cab fares. This paper's contribution would be to evaluate the effect of public transport availability on the use of online cab services like OLA and UBER in pre- and post-lockdown periods. In this context, we examine how COVID-19altered the structure of online cab fare in Kolkata city, India.

Kolkata is one of the eight metro cities of India and the seventh biggest city of India in area and population. As per the 2011 census, the population of the city is 44 lakhs. However, the average annual salary is only Rs. 15 lakh in comparison to the other three metros (Delhi, Mumbai and Bengaluru), where the annual salary is at least Rs. 20 lakh (Hindustan Times 2023). Having lower income, most commuters depend on public transport rather than private individual transport. About 60 lakh commuters typically travel each day from both within and around the greater Kolkata area (Anandabazar Patrika 2020). These commuters mainly depend on public transport like buses, metros, and local trains for their commute. After lifting of the lockdown, in the initial period, the local trains and metros were not operating, due to which, commuters had to depend on buses for public transport. Further, private buses were not operating in the first few days from June 1-3, 2020. This created an additional public transport supply constraint for the low-income group, who had to commute to sustain their livelihood. The shortage of public transport would lead to rise in the demand for online cab-services and increased cab fares. However, this increase in demand for online cab-services would be purely due to supply constraint rather than commuter's behavioral change pattern for safe travel to avoid contracting SARS virus. In the former case, the increase in demand for online cab-services would be short-lived and reduce with adequate public transport, however in the latter, there would be a long-run impact on the demand for online cab-services.

In Kolkata city, as per the central government guidelines, a lockdown was imposed from March 25 to May 31, 2020. The study uses balanced panel data on daily app-based cab fare for different time zones before and after the lockdown. Using the fixed effect methodology, the study aims to segregate the effect of COVID-19 from public transport shortage on the online cab fare.

The purpose of the study is to analyze the effect of lockdown restriction and public transport supply constraint on app-based cabs fare. The entire study is divided as follows. The literature survey on online cab service is explained in the following section. Next, the model and explanatory variables adopted in the study are explained. The result and analysis are explained later. Finally comes the discussion and conclusion.

Literature Review

The online cab service and app-based cab service have recently garnered importance in the field of research (Luciano et al. 2023, Rizki et al. 2021). Cramer and Kruger (2016) have shown that app-based cab service like UBER is more efficient than a traditional yellow taxi in matching the commuters with the drivers, using their technology. Hence, they both reduce the search costs of both commuters for cabs and cab drivers for potential riders. Further, Hall et al. (2018) in their study of US metropolitan cities empirically validated that online cab services like UBER complemented the use of public transport by providing the fixed route of public transport more flexibility and increasing the use of public transport.

Literature on online application-based cabs have been broadly divided into two categories: analyzing either the customer experience, examining their business model or predicting the use of app-based cab services like OLA or UBER. A few studies (Nikam et al. 2020, Kalla and Purohit 2017) performed a detailed analysis of the business model employed, particularly by OLA. Alemi et al. (2018) determined the factors that influence the commuters to use online cab services like UBER. They found that the more educated and technology-driven millennial generation frequently use UBER. Further, accessibility of a location by automobiles plays an important factor in using online cab-service. Some empirical studies (Perea and Samarasinghe 2020, Khuong and Dai 2016, Soleh et al. 2018) evaluate the major factors that determine customer's satisfaction and customer loyalty for app-based cabs. Price of the app cab has been found to play a significant role on customer's satisfaction (Perea and Samarasinghe 2020, Khuong and Dai 2016, Soleh et al. 2018). A study on e-biking in Indonesia revealed that COVID-19 has made the condition of app-based drivers vulnerable (Rachmawati et al. 2021). There is no study to show the effect of public transport availability and dual shifts of jobs on app cab fare. The current study fills this gap in this literature by examining how public transport, government policies like dual shifts and infrastructure blockage impact online cab fare.

Methodology and Data

According to the demand-supply framework, the app cab fare in a locality for a particular time of the day depends on demand for cabs and availability of the online cabs there at that moment. Hence, during high demand for cabs compared to the availability of cabs, usually a peak price loading occurs, which drastically surges the cab fares compared to normal times (OLA 2022). During the pandemic, the Government of India announced a nationwide lockdown (restriction in movement and all forms of activity) from March 25 to May 30, 2020 to prevent rapid spread of COVID-19 among people. The restriction in movement issued by the government during lockdown and further the fear of spread of COVID-19 by contact led to social distancing and self-imposed confinement in houses. Even after the lifting of lockdown on May 30, 2020, the availability of both public transport and online cab services was significantly curtailed. On the other hand, the fear of contracting COVID-19 increased people's propensity to switch from public transport to online cab service. Both these factors would cause an increase in the demand for online cab service.

In addition to the online cab service, Kolkata also has the traditional yellow cab services. The localities will themselves play an important role as these yellow cabs will be competitors for online cab service and their availability in an area would affect the online cab fares, (Cramer and Kruger 2016). The zones for this study were restricted to regions where OLA and UBER service was available and could not be chosen randomly (Economic Times 2020). If we consider only cross-section, the analysis will suffer from cross-section bias, for example, the availability of yellow cab services would affect the extent of lockdown on both

transport and fares. Similarly, considering only time series data can incorporate time series bias. Gradually, exposure and familiarity to online cab service will enhance the usage of online cab service (Alemi et al. 2018). To remove both cross-section and time series bias, the study uses a fixed effect panel methodology (Baltagi 2005). The following fixed effect model tries to capture the essence of the previous discussion and removes the cross-section and time series bias:

$$(pit) = \alpha_0 + Number\ of\ Active\ Cases\ \beta_1 + Lockdown_{it}\beta_2 + Number\ of\ Active\ Cases * Lockdown_{it}\beta_3 + Private\ Bus\ Operation\ \beta_4 + \mu_i + \varphi_i\ (t) + \vartheta_{it};$$

$$i = Distance\ zone, t = Time\ of\ a\ day \qquad [1]$$

The dependent variable online cab fare $'pit'$ in a locality $'i'$ in any particular $'t'$ time of day would be dependent on many factors. The unobserved individual locality factors are captured by μ_i , $\varphi_i\ (t)$ captures the trend of cab fare and ϑ_{it} represent the random error term. Our primary interest lies in the coefficient of regression variable $'Number\ of\ Active\ COVID-19\ Cases' * Lockdown,$ which represents change in in travel behavior pattern to maintain social distancing following the lockdown. With an increase in COVID-19 active cases following lockdown, is there rise in online demand for cab-services due to social distancing? The coefficient β_3 represents the online cab fare affected by COVID-19 cases in a particular locality since it is in a more restricted area with fewer transport options as opposed to a less restricted area with more options following lockdown. Our secondary concern is the coefficient β_4 effect of private bus operation dummy variable on cab fare. Hall et al. (2018) found that in the US metropolitan cities, the use of online cab services complemented the public transport services by increasing their usage. However, the lower income commuters would be mainly captive users, who are dependent on public transport as it is a cheaper mode of transport; hence public transport would act as a substitute for private cabs. Therefore, whether the majority of the commuters are captive users would determine the net effect and relationship of public transport as a complement or substitute for online cab-services. Additionally, we also explore the effect of dual shift for government employees and weekends on the cab fare. The dual shift of government employees would allocate demand between different times of the day and hence decrease pressure on demand for transport and reduce online cab services. Weekends would require only travelling for leisure, which would lead to a major reduction in leisure travel following COVID-19 (Kim et al. 2021).

Temporal and Geographical Scope of the Study

The initial phase of COVID-19 before lockdown and after lifting of lockdown from March 10 -June 17, 2020 (with breaks) in Kolkata is the study period. WHO declared COVID-19 as a pandemic on March 11, 2020. The first case of COVID-19 was recorded on March 17, 2020 in Kolkata. Following that, there was an upward trend of COVID-19, cases and in an effort to stop the pandemic from spreading, the central government imposed a nationwide lockdown from March 25–May 31, 2020 in line with other industrialized countries like France and Germany. During this lockdown period, public transport and all forms of activities, except movement for emergencies, were suspended.

Explanatory Variables

The dependent variable APP cab fare is collected from primary data of online apps (OLA and UBER) on daily basis from March10 -June 17, 2020. Usually before commencing any ride, for these APP cabs, the commuter is shown the prospective fare based on its current location and time; this fare has been considered for the study as the main dependent variable. We record the app cab fare on daily basis for different zones before and after the lifting of COVID-19 lockdown. The authors recorded the required cab fare data from OLA and UBER online apps for each zone, on a daily basis for different time periods. The entire cross-section was divided into seven zones, with ascending order of distance required to be travelled, respectively for each zone. The details of the different zones are provided in Table 1. Further, the app cab fare was collected on daily basis for three different time periods: morning (8a.m.-9:3a.m.), afternoon (12:30p.m.-2p.m.) and evening (5p.m.-6:30p.m.) to capture peak pricing of cab fare. As both OLA and UBER are prominent players for online cab services in Kolkata, for each zone, fares of both the app cabs were initially noted and then the average of the two fares for a zone at a particular time was considered. Since the services of online app cabs like OLA and UBER were not available during the interim period (March 25-May 31, 2020), when the central government announced a complete lockdown, a balanced panel of 294 observations were collected. Hereafter, we will refer to OLA and UBER as app cabs for the rest of the study.

Table 1. *Description of Zones of App Cab for Study*

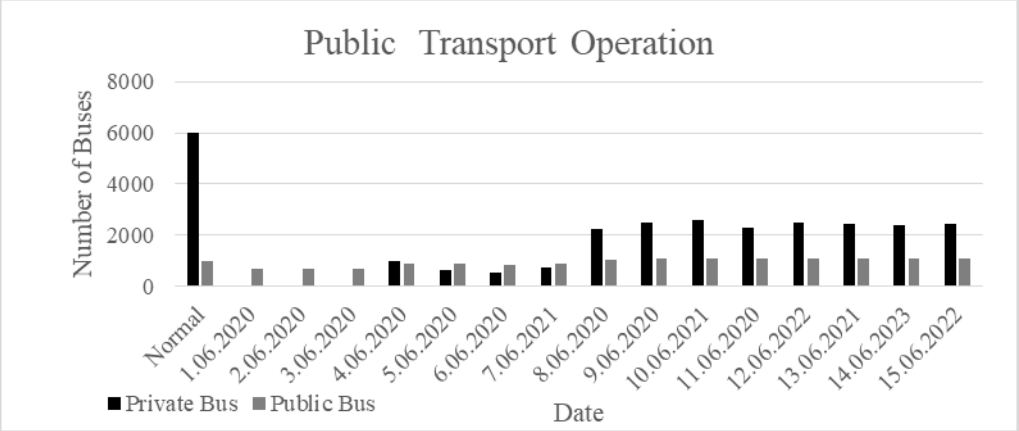
Zones	**Distance (in km)**
MAIDAN - PARK STREET	5
BOTANICAL GARDEN – BENIAPUKUR	7
BENGAL CHEMICAL – TOPSIA	9
LAKE TOWN – BOSEPUKUR	12
DAKHINESWAR – SANTOSHPUR	15
BELGHORIA - SHAKUNTALA PARK	18
JOKA - KAMALGACCHI MORE	21

Source: Based on Authors Calculation of App Cab Fare Data.

The other major explanatory variables for this study are the number of active COVID-19 cases in Kolkata. The West Bengal government has been updating the number of active cases of COVID-19 in Kolkata on a daily basis on its COVID-19 website. We collected data on the daily active cases in Kolkata from this website. We included a lockdown dummy to account for the decrease in public transport availability after the lifting of restrictions on movement from May 31, 2020 onwards, as compared to the pre-COVID-19 period.

Most of the commuters in Kolkata city depend on private buses, which are almost six times as numerous as government buses. The metros and local trains also provide vital modes of public transport, but during the initial period of lifting of lockdown, these modes were not operating. Hence, the ordinary commuter had to depend mainly on buses for commuting to their destinations. However, the private bus owners initially refused to resume bus services from June 1-3, 2020 even after the lockdown was lifted from June 1, 2020, in order to negotiate for a fare hike in consideration of cost increase. Although, private buses resumed service from June 3, 2020, they were operating only 30 percent of their usual capacity, as is evident from Figure 1. We include a dummy variable for private buses operating with operation period as one and otherwise zero. This allows to capture the massive supply constraint of public transport caused by private buses not being operational from March 25, to June 3, 2020.

Figure 1. *Access to Public Transport Availability before and after Lifting the Lockdown*



Source: Assorted Issues of Anandabazar Patrika (2020).

With respect to the public transport supply constraint the commuters were experiencing, the West Bengal government introduced a dual shift for government employees, to reallocate the demand of public transport from peak to slack period. To capture this dual shift, we use a dummy variable whose value equals one for time period June 11, 2020 onwards and zero otherwise. We also include a dummy variable to differentiate the travel behavior between weekdays and weekend, with weekends equal to one and zero otherwise.

As shown in Table 2, the average APP cab fare in Kolkata increased by 5 percent after the lifting of lockdown in comparison to the pre-COVID-19 period, when transport availability was normal. Approximately 85 percent of the private

buses were operating before lockdown, compared to only 71 percent after lockdown was lifted.

However, as seen in Figure 1, there was a significant drop in the number of buses operating and only 30 percent of the normal scenario were available to commuters. After the lockdown was lifted, additional weekend days were taken into account in the sample data. We also observe that before lockdown there was no dual shift, but after lifting lockdown, in approximately 50 percent of the cases, the government employees could opt for dual shift to perform their duties.

Table 2. *Comparison of Average APP Cab Fare before and after Lockdown*

	Before Lifting Lockdown	**After Lifting Lockdown**
Average Cab Fare	304 (77)	319 (85)
Private Bus Operation Dummy **Private Bus operation=1, otherwise=0**	0.857 (0.351)	0.714 (0.453)
Weekends Dummy **Weekends=1, Weekday=0**	0.143 (0.351)	0.286 (0.453)
Dual Shift of Government Jobs Dummy **Dual Shift=1, otherwise=0**	0 (0)	0.429 (0.497)
Number of active COVID-19 cases	132	1450
Observations	147	147

Source: Based on Authors' Calculation of App Cab Fare Data. The standard errors are mentioned in parentheses.

Results and Analysis

The results of the study in hand are presented in this section both graphically and analytically.

Graphical Analysis

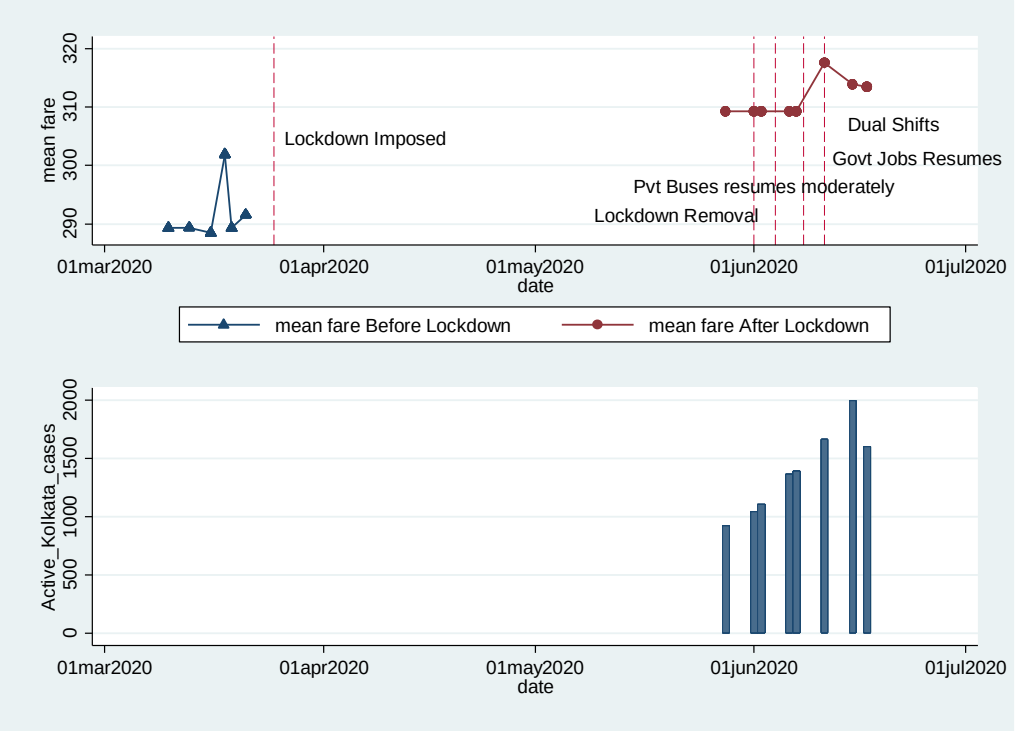
Figure 2 is a graphical representation of the average app cab fare before lockdown was imposed and after lockdown was lifted in 2020. In the first panel and number of active COVID-19 cases in the second panel. As the regular cab services were not available from March 25 to -May 31, 2020 during the central lockdown, there is a gap in the data. It is evident that there is a discrete jump in the average app cab fare to Rs. 319 from Rs. 302 after the lockdown in comparison to before the lockdown. Interestingly, it is observed that during the pre-lockdown stage there is an increase in the demand for APP cabs, which is reflected in the cab fare. This is coinciding with the first positive case of COVID-19 diagnosed in Kolkata on March 16, 2020. Further, the volatility in the fare has increased after the COVID-19 in comparison to the normal period before imposition of the lockdown.

The second panel depicts the number of active COVID-19 cases in Kolkata on a daily basis. There has been an increasing trend in the COVID-19 cases after the lifting of lockdown. Although, Kolkata had already seen few COVID-19 cases

before imposition of the lockdown, due to range of scale, it is not depicted visually here.

The vertical lines represent different structural breaks that occurred and their effect on the cab fare. The first and foremost structural break was the imposition of nation-wide lockdown on all modes of transport and activities from March 25, 2020. The second structural break was in the form of lifting of lockdown from June 1, 2020. The third line depicts the partial availability of private bus transport in addition to the government buses in Kolkata from June 4, 2020. Although, in Kolkata, most of the commuters rely on private buses rather than the West Bengal government buses, only thirty percent of the regular private buses were operating in order to negotiate for a hike in bus fare. The next structural break was in the form of reintroducing work from office for government employees from June 8, 2020. Lastly, the government employees were allowed to operate in dual shifts to ease the commute problem after lifting the lockdown from June 11, 2020.

Figure 2. *Comparison of APP Cab Fare before Imposition and after Lifting Lockdown*

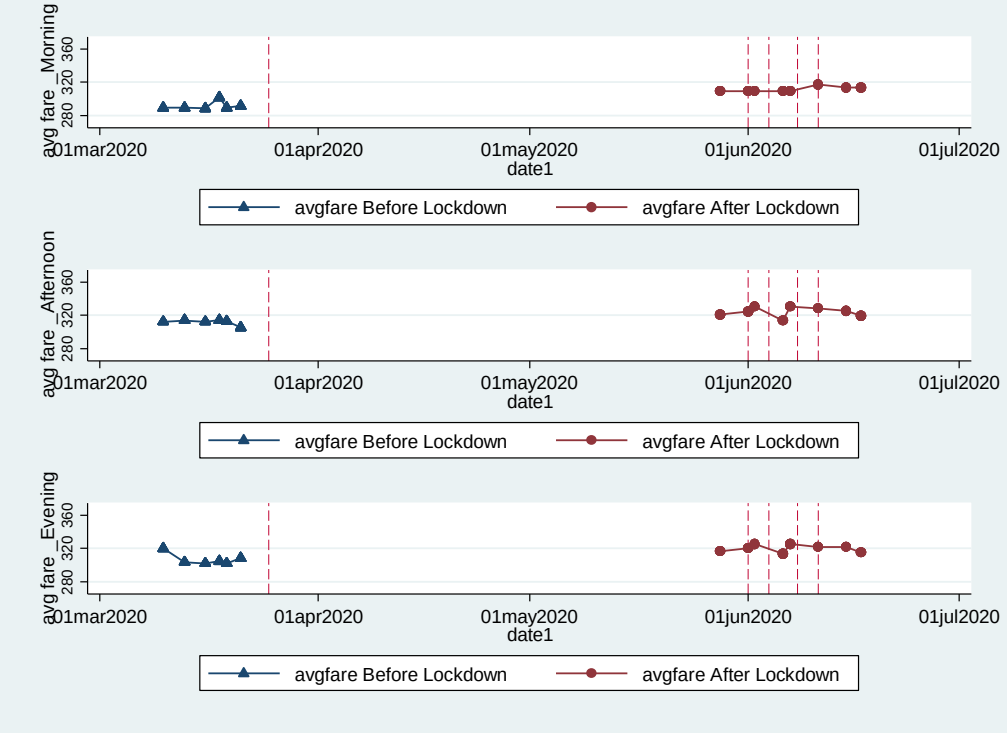


Source: Based on Corona Bulletin of West Bengal Government and Authors' Calculation of App Cab Fare Data of OLA and UBER.

Figure 3 graphically represents the average APP cab fare during the different time zones namely morning, afternoon and evening on a daily basis before the imposition of lockdown and after the initial lifting of lockdown in Kolkata. Usually, the demand for transport varies between office hours (peak period) and non-office hours (slack period). Further, with a supply constraint of public transport in the form of private buses, this would directly translate to demand for

APP cabs. Here, peak office hours are in the morning and evening and the slack period is in the afternoon.

Figure 3. *Comparison of APP Cab Fare during Different Time Periods of the Day*



Source: Based on Authors' Calculation of App Cab Fare Data of OLA and UBER.

Few observations are worth noting from the above graphical representation of the daily average APP cab fare for various time zones of the day. Firstly, irrespective of the time of the day, there has been a hike in average cab fare in the post-lockdown stage compared to the pre-lockdown stage; however, the hike is significant mostly in the morning. Further, after the introduction of dual shifts for government employees, there has been a shift in the demand from afternoon to morning commute. This can be explained by the fact that usually the government employees have relaxed office hours compared to the private job employees and they were not penalized for late entry during this period. However, due to the introduction of dual shifts, a considerable section of these government employees had to start their shift from 9 am and the other section started their shift from 12 pm. As a result, after the introduction of the dual shifts, the demand for morning commute increased and evening commute decreased, as some of the government employees would have already completed their shift by 2:30 p.m. and left for the day. Hence, there is a surge in the morning cab fare and reduction in the evening cab fare after June 11, 2020. This indicates a reallocation of demand for transport between various time zones of the day.

Effect of COVID-19 and Public Transport Availability in Cab Search Behavior

The existing literature on transport has found a shift in preferences from public to private mode of transport for the commuters after COVID-19 in many countries. Empirical studies (Paul et al. 2022, Meena 2020) found that low-income commuters from developing countries are still dependent on public transport to sustain their livelihood, besides choosing cycling or walking. Due to unavailability of real time travel data of private transport like personal cars, bikes or bicycles in this study, we consider the demand for APP cabs as a proxy for private transport preferences. Interestingly, Paul et al. (2022) found that the demand for online cab services and taxis increased in our neighboring country Bangladesh in the post-COVID-19 period. The objective of the study is to analyze whether online cab-service in the post-COVID-19 period is used by commuters as a safer mode of transport or a compulsion due to lack of adequate public transport. In the former case, there would be an increase in demand for online cab services even after controlling for public transport availability, whereas in the latter case, the demand for online cab services would reduce after controlling for public transport availability. In Kolkata city, approximately 60 lakh commuters depend mainly on private buses compared to public buses, which are few. However, private buses were plying only 30 percent of their capacity during the study period. Further, other modes of public transport like local trains and metros were not available for the public commuters during the study period to restrict the spread of virus. Hence, this allows us to consider the travel choice of commuters under public transport constraint.

In Table 3, comparing columns 1 and 2, we find that there is a significant effect of number of active COVID-19 cases and lockdown on the cab fare initially. The coefficient from the interaction of active COVID-19 cases and lockdown lifting dummy indicates that if there is an additional increase of active COVID-19 cases by 100, then the online cab fare would increase by Rs. 1 in the post-lockdown period. However, column 2 depicts that the driving force behind the demand for online cab is not social distancing due to fear of COVID-19, but insufficient public transport availability as captured by the private bus operation dummy. If the private buses are operational, then it leads to an additional Rs 4 reduction in cab fares as the private buses are a substitute for private cabs. It is driven mainly by the evening rush hours when there is a huge shortage of buses compared to the demand (Anandabazar Patrika 2020). The provision of private buses causes an additional Rs.12 reduction in cab fares. As is evident from columns 3, 4 and 5, respectively, during the weekend, people are demanding less cabs compared to the weekdays when they have the compulsion to travel to work. Weekends may require less traveling in comparison to weekdays, due to which the cab fare reduces by Rs3-5.

Table 3. *Driving Force behind Surge of Cab Fare after Lifting of Lockdown*

	Column1	**Column2**	**Column3**	**Column4**	**Column5**
	All Day	**All Day**	**Morning (8-9:30a.m.)**	**Afternoon (12:30p.m.-2p.m.)**	**Evening (5p.m.-6:30p.m.)**
Number of Active COVID-19 Cases	0.013** (0.005)	0.008 (0.006)	0.017 (0.013)	0.009 (0.009)	0.0007 (0.0081)
Lockdown Removal Dummy	15.636** (-5.158)	6.567 (7.016)	15.323 (16.776)	12.222 (9.791)	-7.843 (8.966)
Active Cases*Lockdown Removal	-0.014** (0.005)	-0.004 (0.008)	-0.018 (0.018)	-0.006 (0.010)	0.013 (0.010)
Private Bus Operation Dummy	-	-4.329* (2.175)	2.043 (2.537)	-2.390 (3.974)	-12.640** (2.648)
Weekend	-2.087** (0.927)	-0.634 (1.708)	-3.340* (1.614)	-3.857** (0.860)	5.295** (1.473)
Trend Effect	Controlled	Controlled	Controlled	Controlled	Controlled
Observations	294	294	98	98	98
Methodology	Fixed Effect	Fixed Effect	Fixed Effect	Fixed Effect	Fixed Effect

Note: **, * Significant at 5% and 10 % confidence level, respectively. The robust standard errors are mentioned in parentheses.

The above results indicate that in the post-lockdown period, commuters choose cabs not as a means of social distancing but due to unavailability of public transport. Especially during peak periods (evening and morning), when public transport is limited, the impact on cab fare is significant. Further, on weekends, when traveling is not compulsory, there is a significant reduction in cab fares.

However, till now, we have ignored the commuter's capacity to choose the time of travel to go to work. In the following section, we will study the effect of the introduction of dual shifts for government employees on online cab service usage.

Effect of Dual Shift of Government Jobs in Shifting Transport Demand

Keeping in view the availability of public transport, private buses were operating only at 30 percent of their full capacity, the Government of West Bengal introduced a dual shift for government employees from June 11, 2020. The morning shift allowed employees to function from 9a.m. to 2:30p.m., and the afternoon shift operated from 12p.m. to 5:30p.m. (Anandabazar Patrika 2020). The purpose of the dual shift was to reallocate the commuter demand for transport and reduce the load on public transport. The result of the analysis of dual shift on APP cab demand is provided in Table 4.

Table 4. *Effect of Dual Shift Introduction on Peak Price Loading of APP Cab Fare*

	Column1	**Column2**	**Column3**	**Column4**	**Column5**
	All Day	**All Day**	**Morning (8-9:30a.m.)**	**Afternoon (12:30p.m.-2p.m.)**	**Evening (5p.m.-6:30p.m.)**
Number of Active COVID-19 Cases	0.008 (0.006)	0.008 (0.005)	0.018 (0.012)	0.007 (0.009)	0.001 (0.008)
Lockdown Removal Dummy	6.567 (7.016)	3.519 (6.127)	18.595 (12.971)	0.453 (8.032)	-8.491 (9.685)
Active Cases*Lockdown Removal	-0.004 (0.008)	-0.001 (0.007)	-0.021 (0.014)	0.004 (0.009)	0.013 (0.010)
Private Buses Operation Dummy	-4.329* (2.175)	-3.908 (2.281)	1.591 (2.820)	-0.764 (4.280)	-12.551** (2.802)
Weekend	-0.634 (1.708)	-1.859 (1.708)	-2.024 (2.679)	-8.588** (1.581)	5.034* (2.082)
Dual Shift of Government Jobs Dummy	-	-2.938 2.307	3.154 (5.027)	-11.342** (2.597)	-0.625 (1.910)
Trend Effect	Controlled	Controlled	Controlled	Controlled	Controlled
Observations	294	294	98	98	98
Methodology	Fixed Effect	Fixed Effect	Fixed Effect	Fixed Effect	Fixed Effect

Note: ** Significant at 5% * Significant at 10% confidence level. The standard errors are mentioned in parentheses.

Comparing columns 1 and 2 of Table 4, we observe that after incorporating the dual shift dummy for government employees, the private buses are no longer acting as a driving force behind app cab fare determination. In other words, the dependency on private bus operation has been considerably reduced for afternoon commuters. After introduction of dual shift for the government employees, cab fare for the average afternoon cab commuter decreased by Rs. 11 or 3 percentage compared to the base fare. However, private bus operations continue to have an impact on cab preference in the evening rush hour, and consequently, the fare. Cab fare reduces significantly by Rs 12 when private buses are operational as opposed to not operational. This is because a smaller number of private buses were operational in the evening than in the morning. This shows that the state government was successful in transferring some of the demand from peak period to off-peak period by introducing dual shift for government employees.

The study so far has considered regional uniformity in availability of public transport. However, usually, not all sections of the city have similar access to public transport. Keeping this in view, we use a natural shock, closure of Tala Bridge for reconstruction in Kolkata that created additional barriers for commuters to access public transport. In the following section, we study the effect of infrastructure blockage on cab fare.

Effect of Infrastructure Blockage on Transport Demand

Infrastructural blockage creates a major problem in commuting and accessing public transport. In a city, not every location may have similar access to public transport during a pandemic. Alemi et al. (2018) found that usage of online cab services depends on regional accessibility by cars. In this study, we use a natural infrastructural shock of Tala bridge closure in north Kolkata for reconstruction purpose from February 2020 to September 2022, to study the impact of infrastructure blockage on transport demand for online cabs services. The commuters in northern parts of Kolkata had been severely affected by the closure of Tala Bridge from February 2020 and unavailability of public transport (Anandabazar Patrika 2020). Under normal circumstances, commuters in northern Kolkata depended on local train and metro for commuting regularly after closure of Tala Bridge for reconstruction. However, after lifting of lockdown, due to metro and local trains not being operational, commuters in this area of the city became dependent on either buses or private transport for regular commuting. In the following section, we segregate the zones of study into those affected by Tala Bridge closure (treatment) and those not affected by Tala Bridge closure (control). In our sample, three zones were affected by Tala bridge closure, and the remaining four zones were not affected by it (refer to Appendix). The result of the analysis is summarized in Table 5.

Table 5. *Effect of Tala Bridge Inaccessibility and Dual Shift on APP Cab Fare*

	Tala Bridge Affected Zones			**Tala Bridge Not Affected Zones**		
	Coulmn1	**Coulmn2**	**Coulmn3**	**Coulmn4**	**Coulmn5**	**Coulmn6**
	Morning (8-9:30a.m)	**Afternoon (12:30p.m.-2p.m.)**	**Evening (5p.m.-6:30p.m)**	**Morning (8-9:30a.m)**	**Afternoon (12:30p.m.-2p.m.)**	**Evening (5p.m.-6:30p.m)**
Number of Active COVID-19 Cases	0.002 (0.010)	0.003 (0.009)	0.003 (0.010)	0.013 ** (0.006)	0.012 * (0.007)	0.013* (0.007)
Lockdown Removal Dummy	-6.868 (12.683)	-3.486 (10.645)	-3.545 (10.625)	13.427 ** (4.356)	8.948 (7.435)	8.817 (7.404)
Active Cases*Lockdown Removal	0.010 (0.013)	0.007 (0.012)	0.007 (0.012)	-0.011 ** (0.005)	-0.007 (0.008)	-0.007 (0.008)
Private Buses Operation Dummy	-9.373** (3.115)	-8.810** (3.370)	-7.995* (4.294)	-1.924 (1.320)	-2.670 * (1.425)	-0.842 (2.209)
Dual Shift of Government Jobs Dummy	-	1.505 (3.014)	0.077 (5.078)	-	-1.993 (1.877)	-5.199** (1.504)
Weekend Dummy	-	-	-1.086 (3.426)	-	-	-2.439 (1.753)
Trend Effect	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled
Observations	126	126	126	168	168	168
Methodology	Fixed Effect	Fixed Effect	Fixed Effect	Fixed Effect	Fixed Effect	Fixed Effect

Note: ** Significant at 5%; * Significant at 10% confidence level. The standard errors are mentioned in parentheses.

As we move from column 1 to 6 of Table 5, the effect of Tala Bridge closure and dual shift is apparent. Firstly, comparing the column 1 and Column 3, we find that the infrastructure blockage is creating major dependency on private bus operation, consequently decreasing the cab fare by Rs 9 in the treatment zones and Rs 2 in the control zones. This is because when infrastructure blockage affects

public transport availability, private cabs may increase their fare. Further, dual shift for government employees has an opposite impact on the treatment zones in comparison to the control zones with respect to private bus operation. Following the introduction of dual shift, private bus operation in comparison to non-operation causes surge in cab fares in the affected areas. However, in the non-affected areas, it is successful in transferring public transport demand and reducing the fares. A potential reason may be that due to infrastructure blockage, public bus accessibility is constrained, reducing the ability to transfer the demand to public transport successfully. Lastly, we find that the number of COVID-19 cases does influence the surge in APP cab fares in treatment areas, compared to the control zones. A possible explanation is that easy accessibility by cars can increase usage of online cab service, leading to increase in cab fare.

Discussion

The purpose of the study was to empirically examine the possibility of online cab service becoming a viable option in a developing country context, following COVID-19, where the lower income commuters cannot afford private cars. The study tried to analyze impact of COVID-19 and public transport constraints on online cab travel choice cab fare, using potential trip information for Kolkata city, India. We considered potential cab trip fares before and after the city was locked down on account of COVID-19 across various locations. We used a fixed effect panel methodology for capturing the attributes of the longitudinal data and to control unobserved location disturbances. We also tried to capture the dual shift of jobs and infrastructure blockage on cab fares.

The modeling outcomes demonstrated the public transport supply constraint was more important in app cab fare determination than the shift in preference to individual transport caused by fear of COVID-19. The key findings are summarized below (i) public transport availability, especially private bus transport plays an important role in online cab fare determination, (ii) dual shifts of jobs are successful in reducing pressure on transport demand and reallocating transport demand during various times of the day, (iii) preference for social-distancing to prevent COVID-19 in the form of personal transport over collective transport is more feasible in scenarios with no infrastructure problem, causing smaller surge in fares, (iv) infrastructure blockage reduces the effectiveness of dual shifts of jobs in reallocating transport demand and usage of online cab services and (v) fare is reduced substantially during weekends and due to dual shifts of jobs.

This study indicates that although social distancing is essential to curb the spread of pandemic, lower income commuters depend on public transport for commuting. There is a high proportion of captive users in Kolkata. Especially, in developing countries like India, where people depend mainly on public transport for commute, imposition of social distancing without adequate public transport would be a failure and only lead to harassment of regular commuters. Hence, planning of adequate availability of public transport along with social distancing would be effective to curb the pandemic. This is similar to the strategy proposed

by Asian Development Bank (Asian Development Bank Report 2020, Asian Development Bank Policy Brief 2022) to encourage use of public transport by enhancing the existing system and implementing new initiatives as a long-term sustainable solution to the urban transport problem in a developing country context. Further, dual shifts of jobs are an effective policy measure, which the government can adopt to transfer the transport demand and prevent the spread of pandemics. Also, this study assesses how a regular commuter benefits from private bus operations. Approximately, there is a decrease of Rs. 5 in cab fare occurs in general due to operation of private buses as opposed to their non-operation. The government can use this data to set a benchmark for hike in private bus fares while negotiating with private bus owners.

Conclusion

This is the first study to attempt an evaluation of the impact of public transport on online cab services in a developing country context, following COVID-19, especially for low income commuters, who mainly depend on public transport. It also tries to highlight the public transport supply constraint following the initial lifting of COVID-19 lockdown. Although these studies reveal the effectiveness of public transport in low-income countries, where people are restricted by income to avail public transport, it suffers from some limitations. The first limitation is that the actual transport trip data of cabs and private and public buses is not included in this study due to lack of availability. The second limitation is the inability to examine the actual number of public transport buses because the data was not officially available. The third limitation of the study is that it cannot capture the effect of other modes of transport like cycling, bikes and walking, which have gained importance following the pandemic and will have an effect on the online cab fare.

The study demonstrates that online cab services can substitute public transport, even in a metropolitan city like Kolkata with good accessibility, where most commuters are captive users with low income. This is in contrast to the findings of Hall et al. (2018). In metros like Bangalore and Mumbai, where commuters have higher income and public transport like local trains or metros acts as lifeline of the cities, online cab service can act as a substitute for public transport. However, it needs to be studied separately as an area of future potential research.

Acknowledgments

We are thankful to Dr. Mamta Kumari, Dr. Anupam Tyagi and Dr. Debabrata Dutta for their invaluable comments, which have enriched this study.

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Appendix

A1. *Segregating Zones Affected due to Tala Bridge Closure*

Zones	Distance (in km)	Tala Bridge Closure
MAIDAN - PARK STREET	5	Unaffected
BOTANICAL GARDEN - BENIAPUKUR	7	Unaffected
BENGAL CHEMICAL - TOPSIA	9	Unaffected
LAKE TOWN - BOSEPUKUR	12	Affected
DAKHINESWAR - SANTOSHPUR	15	Affected
BELGHORIA - SHAKUNTALA PARK	18	Affected
JOKA - KAMALGACCHI MORE	21	Unaffected

Athens Journal of Health & Medical Sciences – Volume10, Issue 4, December 2023 – Pages 269-286

Linguistic Complexity of Patient Information Leaflets: A Coh-Metrix Analysis

By William Kodom Gyasi[*]

The present study explored linguistic complexity of patient information leaflets based on the Coh-Metrix analytical tool. Using 100 patient information leaflets of seven common ailments in Ghana, the researcher analyzed the lexical and syntactical features of the leaflets to ascertain their linguistic complexity. The results revealed patient information leaflets are lexically dense except the leaflets for dewormer which were written at moderate level. Also, the study revealed that the patient information leaflets were syntactically complex. However, a comparative analysis of the leaflets across ailments revealed no significant difference in the syntactical and lexical densities among the leaflets. The researcher recommends that further studies be conducted in other health information documents to ascertain their linguistic complexity.

Keywords: *readability, lexical density, syntactical complexity, Coh-Metrix, patient information leaflets, health communication*

Introduction

Humans desire good health because it is the best way to live for long. Quality health care delivery requires effective communication between practitioners and patients. Public service announcement through the use of information centres, national media and outdoor media is not new in the Ghanaian society. Information on sanitary practices, hygienic practices and precautionary and preventive measures are communicated through the public service announcements.

Bernhardt (2004) found that the relationship between communication and health has rapidly developed and expanded. Health communication involves strategic dissemination of relevant health information to influence behavioral change among people (Schiavo 2013). Health communication could be done through print, verbal, multimodal and other effective formats. Patient Information leaflets is a print health communication document.

Patient Information Leaflets contain information about the drug or medication from manufacturer to consumer. It is obligatory to put package leaflets in all medicine packages. It is expected read the leaflets to know more about the drug and how to use it well for maximum results. The use of clear and precise language is key in the development of effective and appropriate material.

McLaughlin (1969) defines readability as "the level at which particular individuals find a particular text captivating and understandable." Readability enhances writer's effective communication with readers as well as the level of comprehension of text by a reader. Through the use of readability formulas,

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manufacturers could have an objective idea of the reading ease level of their patients' information leaflets. Since medical terminologies and technical writing are unavoidable in PILs, the need to guard that through readability scores is advisable.

Patients information leaflets is key information document for patients in the absence of health professionals. However, available studies on leaflets have indicated that they are difficult to read and understand. In UK, Williamson et al. (2010) found the readability of patient's information leaflets above patient's comprehension. In Midwestern urban area, Wilson (2008) found that patients' information leaflets were written too high for the less educated adult.

UK again, Bradley et al. (1994) studied the readability of the leaflets of over-the-counter (OTC) drugs and found that reading score is above the mean reading age of the general adult population. Likewise, a study by Auta et al. (2011) and Clerehan et al. (2005) on the readability of patient information leaflets revealed that leaflets were written at a difficult to read level. The only known study in Ghana on PILs is by Gyasi (2013) which was on common malaria drugs used in Ghana. Gyasi (2013) found that the PILs of the drugs were difficult to read.

While his study was based on only malaria information leaflets, there is the need for further studies to consider other common ailment in Ghana information leaflets to ascertain their readability and comprehensibility to patients. This is crucial because issues regarding the use of medicine are a matter of life and death. Moreover, there is no known study in Ghana yet that examined the readability of the patient information leaflets and the comprehensibility difficulties readers face in using the leaflets for relevant information about the drugs they use to treat common ailments.

The purpose of this study is to examine the readability and comprehensibility of Patients Information Leaflets of over-the-counter drugs of seven (7) common illnesses in Ghana. These illnesses are common cold (flu or catarrh), cough, body pains, diarrhoea, heartburns, sleeplessness and constipation. These illnesses are usually treated through the use of over the counter drugs from licensed medicine sellers.

Research Questions

1. Are there statistically significant differences in the lexical density and syntactic complexity of PILs of OTC drugs across illnesses?
2. Do consumers read PILs of OTC drugs and if they do, do they understand what they read?
3. Is there a correlation between the readability of PILs of OTC drugs and consumers response?

Literature Review

Health communication is vital in health care delivery. Effective health communication is important in mitigating diagnostic challenges, side effects of

drugs and overdose of drugs by patients. The use of patient information leaflets in over the counter drugs sales help users of drugs to know what the drugs contain, the directions of use, the precautions, and the side effects of the drugs. As an information tool, PILs will be relevant to patients if the message in the leaflets are understandable to the patients (users). Readability of PILs is one indicator of the level at which readers will succeed in understanding the leaflets. Readability of PILs in previous studies have revealed that PILs are written at the difficult to read level. Gyasi (2013) discovered that common malaria drugs leaflets in Ghana are difficult to read. Likewise, Wilson (2008) discovered that PILs are difficult to read for an average reader in the western world. The current study was therefore of the view that the communication between manufacturers and patient through PILs could be improved through the production of readable PILs. Even though studies have found PILs to difficult to read, there are limited studies on how over the counter drugs leaflets readability scores affect readers understanding of the leaflets. To fill this gap, the researcher sampled 68 PILs of seven common diseases in Ghana and run a readability analysis of the selected leaflets. The researcher used Flesch Kincaid grade level and SMOG readability formula to measure the readability of the leaflets. The grammatical and lexical density of the leaflets were determined through the Coh-metrix index which measures grammatical density and lexical density. Using Shannon and Weaver's Communication Model, the researcher analyzed the results of the study and came out with these findings.

Grammatical Complexity Analysis

The grammatical complexity of the texts was assessed using Coh-Metrix 3.0. Coh-Metrix is a leading theoretically grounded, computational linguistics analysis facility that analyses texts on multiple levels of language and discourse (McNamara et al. 2014). Coh-Metrix 3.0 measures 108 linguistic features.

For the purpose of this study, I considered Coh-Metrix' *syntactic complexity* measure as a fitting measure of grammatical complexity. This approach is not out of line with that used in Martiniello's (2009) study of the linguistic complexity of math tests for English language learners. There appears to be an overlap between the bank of indices used to measure syntactic complexity in Coh-Metrix and those acknowledged by Lourdes (2015, p. 492) as commonly targeted for "quantifications when characterizing" linguistic complexity. In this study, grammatical complexity is approached from the second definition of 'complexity' distilled from the literature by Pallotti (2015, p. 2); this definition is concerned with "processing costs" or difficulties that are "associated with linguistic structures". This approach justifies the use of the *syntactic complexity* measure of the Coh-Metrix facility, because the indices that make up the measure are deemed to be directly or indirectly indicative of the processing load or difficulty that a piece of writing presents to a reader (Dowell et al. 2016, McNamara et al. 2014). In the light of the elusive nature of a definition for grammatical complexity (Rimmer 2006), it may be argued that the measure of that construct in this present work could have

encompassed *syntactic pattern density* as measured in Coh-Metrix. While this argument may have its merits, I nevertheless chose to restrict the operational definition, and therefore the analysis of grammatical complexity in this work to *syntactic complexity* as measured by Coh-Metrix.

The seven individual indices by which Coh-Metrix measures syntactic complexity are:

- Left embeddedness (SYNLE), that is, the number of words before the main verb in a sentence. Coh-Metrix measures the number of words before a main verb in each sentence, and then calculates a mean across the sample text.
- Number of modifiers per noun phrase (SYNNP). Coh-Metrix counts the number of words before the main verb in each sentence, and then calculates the mean across the sample text.
- Minimal Edit Distance (SYNMEDpos), for parts of speech.
- Minimal Edit Distance (SYNMEDwrd), for all words.
- Minimal Edit Distance (SYNMEDlem), for lemmas.
- Sentence Syntax Similarity (SYNSTRUTa), for adjacent sentences.
- Sentence Syntax Similarity (SYNSTRUTt), for all combinations, across paragraphs.

Each of the indices above is a theoretically and conceptually valid way to measure syntactic complexity (McNamara et al. 2014). However, in this work, I employ only the first two indices, that is, left embeddedness (denoted for brevity as SYNNLE) and mean number of modifiers per noun phrase (denoted for brevity as SYNNP). These should be sufficient indication of text complexity and therefore difficulty based on the notion that "[t]he syntax in text tends to be easier to process when there are shorter sentences, few words before the main verb of the main clause, and few words per noun-phrase" (McNamara et al. 2014, p. 70). According to Graesser et al. (2004), difficult syntax often involves dense structures, ungrammatical forms, ambiguity, and the use of embedded constituents. These attributes lend the difficulty to the processing and comprehension of complex syntax (Perfetti et al. 2005).

The syntactic complexity scores reported in this study are interpreted according to normative scores published in the Appendix B of the book "Automated evaluation of text and discourse with Coh-Metrix" (McNamara et al. 2014).

To create these norms, the author analyzed a subset of a large corpus of texts created by the Touchstone Applied Science Associates (TASA), Inc. The total TASA corpus includes 9 genres consisting of 119,627 paragraphs taken from 37,651 samples. The norms are provided for the three largest domains represented in TASA: language arts, social studies, and science texts. To do so, [the authors] randomly chose 100 passages from each of the 3 genres and each of13 grade levels, for a total of 3,900 passages. Grade level in the TASA corpus is indexed by the Degrees of Reading Power, which is a readability measure that includes word- and sentence-level characteristics. As can be observed in the table, DRP is highly

correlated with the Flesch Reading Ease and Flesch-Kincaid Grade Level measures of readability. To simplify the data analysis and presentation, DRP levels were translated to their corresponding grade-level estimates and then collapsed according to the grade bands used within the Common Core State Standards: grades K to 1, 2 to 3, 4 to 5, 6 to 8, 9 to 10, and 11 and higher. Each grade level within each genre was represented by 100 passages. Because the Common Core grade bands include different numbers of grade levels per band (e.g., 2–3 includes two grades, 6–8 includes three grades), there are different numbers of passages represented for each grade band (McNamara et al. 2014, p. 253).

Apart from descriptive indices, the norms published in the Appendix B of the aforementioned book provide normative values that can be used to compare other texts in the corresponding genre. Because PILs are published in the field of medical field, they fall under the science genre. Therefore, the syntactic complexity scores for these PILs were rightly compared to the norms in the science genre in order to arrive at conclusions on their suitable grade levels.

Text Selection for Grammatical Complexity Analyses

For the sake of uniformity, I selected those same parts of the PILs for grammatical complexity analysis as I did for the readability and lexical density analyses. However, in pre-processing text samples for analysis, I was guided by Dowell et al. (2016). Accordingly, I adopted the following guidelines.

1. If there was not good reason to delete any part of the sampled text, I left it in. The principle behind this was to present texts for analysis that were as close as possible to what the authors intended. Unlike in the case for readability analyses, I found no work that recommended or even suggested that punctuations, bulleted points, etc. could throw off Coh-Metrix measures. Therefore, I left these in the texts.
2. I ensured consistency in the treatment of selected texts. This means that for any modification(s) I made in any one text, I made sure to make same modification(s) in all other texts.

Data Analysis

IBM SPSS® Statistics version 20 was used to conduct both descriptive and inferential statistical analyses of the data. Firstly, the data organised in the MS Excel worksheet were copied and pasted in a pre-coded worksheet in SPSS.

Secondly, simple descriptive statistics were conducted in order to organise and summarise the characteristics of the sampled texts (Tavakoli 2012) in terms of their readability scores, their sentence and word characteristics, their lexical density scores, and their grammatical complexity scores. The information

generated included maximum values, minimum values, Means, and Standard Deviations. This information was presented in tables in the Results chapter.

Thirdly, in order to make a choice between parametric and non-parametric inferential statistics tests, I conducted the Shapiro-Wilk test of normality. Parametric tests of significance require that the distribution of the sample scores be normal or near normal. This requirement is especially important where, as in this work, the researcher has to work with small sample sizes (Tavakoli 2012). The Shapiro-Wilk test was chosen because it is suitable for sample sizes less than 2000. Another requirement of parametric tests is the symmetry of the distributions, or the homogeneity of variance, among the various groups under study. I conducted Levene's test of homogeneity of variance.

In fourth place, I conducted a parametric Analysis of Variance procedure, to test the statistical significance of differences, if any, among the readability, lexical density, and grammatical complexity scores of the PILs.

Research Design

The nature of this study indicated that a non-experimental descriptive approach was the appropriate design. In a non-experiment study, such as this one, there is neither controlling for nor manipulation of some phenomenon of interest and then measuring the effect or outcome of such control or manipulation , (Bhattacherjee 2012; Cresswell, 2009). Descriptive research rather involves making observations of a phenomenon of interest and recording these observations as they are presented (Tavakoli 2012). In this work, observations of the reading difficulty levels of the CMI/PILs were made via online readability testing, and the quantitative scores were recorded. The means of the readability scores of the groups were compared; but the comparison did not preclude the study from being descriptive (Tavakoli 2012).

CMI/PILs Description

Seven groups of CMI/PILs were tested for reading difficulty. The documents were grouped according to the ailments or conditions for which their respective medicines were indicated. The medicines fell under these types: appetite stimulants, cold and flu medicines, cough preparations, dewormers, gastrointestinal reflux relievers, haematinics, and pain medication.

Each leaflet was published by the manufacturer of the respective medicine. The leaflets came in a variety of font styles and sizes, document lengths, font colours, and quality of paper. For each document, the publishers had organised the information into specific rhetorical sections, or moves, with appropriate headings. The leaflets varied in the number of these sections that they contained. The commonest headings included *composition* and *pharmacological information* (sometimes presented as *pharmacological action*, *pharmacodynamics* and *pharmacokinetics*, or simply *actions*). Other common sections were *indications*,

contra-indications, *dosage and administration*, *drug* (and *food*) *interactions*, *side effects*, *warnings and precautions*, usage in *pregnancy and lactation*, symptoms and treatment of *overdosage*, *storage* instructions, *presentation* of the medicine, and manufacturer information. In a small number of leaflets, there were sections that covered their respective medicines' effect on driving and operating machinery. All CMI/PILs were observed to have *shelf life* information, and also dates of publication and or revision of the document.

In a small number of leaflets, it was observed that the publishers had deliberately endeavoured to explain the sections rather than just give them titles. For example, in the leaflet for Rhinathiol® Expectorant Carbocisteine 5% Syrup for Adults, rather than simply state 'indications', that section is titled "WHAT (sic) Rhinathiol Expectorant Carbocisteine 5% syrup for adults IS AND WHAT IT IS TAKEN FOR (sic)". In the same document, "breast-feeding" is used instead of the commoner "lactation". Another example of this case is the packet leaflet for Vermox® 20mg/ml oral suspension. In this case, instead of "presentation", that section of the document is titled "What Vermox suspension looks like and contents of the pack". Further in this case, the usually distinct *composition* section is situated under a section titled "further information", where it is broken into "active substance" instead of "active ingredients", and "the other ingredients" instead of "excipients". It was observed that documents that employed such simplification of expression generally opened with an index of the various sections or moves in the document.

Sampling Techniques

Leaflet Collection and Selection

The package leaflets were conveniently sampled. With proper permission, and the help of a certified pharmacist, the researcher collected package leaflets from patients who bought medication from the OPD Pharmacy of the Cape Coast Teaching Hospital.

Over the collection period, a total of 100 were collected. However, after sorting it was found that some of the leaflets were the same, hence the researcher used 68 leaflets. The extra leaflets were culled from the collection.

Each document was scanned into a jpeg file at a high dot-per-inch setting using a hand-held SkyPix TSN410 Handyscan scanner. The scanned documents were individually converted to editable text by means of ABBYY Screenshot reader, an optical character recognition (OCR) software.

Text Selection

Blocks of text were selected from each document for readability analysis. The text selection was criterion-based. Criterion-based sampling, also known as judgmental sampling, is a non-probability process wherein cases sampled are selected on the basis of the researcher's typicality, the researcher's judgment, or

otherwise on predetermined criteria (Tavakoli 2012). A primary criterion for selecting text was based on the findings of Raynor et al. (2007) that the parts of medicine information leaflets that were most likely to be read were, in that order, side effects, administration, and indication. A three-decade old study had shown that the items on a packet leaflet most likely to be recalled by patients were directions for use and side effects or adverse reactions (Morris et al. 1977, Auta et al. 2011). The side effects, administration, and indications sections respectively provide information on possible adverse reactions to the medicine, how and when to take the medicine, and what conditions or ailments the medicine is intended for. In keeping with the finding of Raynor et al. (2007), I selected the following sections for inclusion in sampled text: *Indications*, *Contra-indications*, *Adverse reactions*, *Warnings and special precautions*, *Overdosage and treatment*, *Dosage*, and *Pregnancy and lactation*. Where available, texts from sections such as *special populations* were also included in the readability analyses. Based on my subjective judgment, I excluded sections such as *pharmacological actions* and *pharmacokinetics* from the analyses; these routinely contained many technical jargons and appeared to have been written for the benefit of health professionals and not the average patient.

In cognizance of the fact that bulleted lists, tables, equations and headings were not among the materials used to develop the formulas (Schriver 2015), I cleaned the sampled texts to remove headings, and to replace contractions, abbreviations, elisions, and initialisms with their full forms. For in instance, "etc." was replaced by "and so on"; "%" was replaced with "percent"; and "mg" was replaced with "milligram(s)".

Readability Analysis

Each final sample was analysed for readability using the online calculator at https://www.readabilityformulas.com. While the calculator returned readability scores from eight different indexes, I only recorded scores for SMOG and Flesch-Kincaid. Other data I recorded were: word count of sampled text, average number of words per sentence, average number of syllables per word, and percentage of multisyllabic words (≥ 3 syllables).

Results of the Study

Lexical Density of the PILs of the Seven Groups of OTC Medicines

Table 1 presents a quantitative description of the lexical densities of the seven groups of PILs tested in this study. In this study, Ure's redefinition of lexical density was employed. According to the definition, lexical density is a ratio of lexical items to grammatical items (Ure 1971) expressed as a percentage. This means that the lexical density values in Table 9 are percentages of words in sampled texts that have lexical or meaning-bearing value.

Table 1. *Quantitative Description of Lexical Density of PILs*

	N	Minimum	Maximum	Mean	Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Statistic
Appetite Stimulants	11	50.87	72.78	59.8809	7.17752
Cold and Flu medicines	7	46.29	84.21	61.0314	12.59833
Cough preparations	9	45.65	76.14	64.9522	8.92367
Dewormers	9	37.97	62.69	51.9467	7.52005
Gastrointestinal reflux relievers	7	50.80	63.34	56.6771	4.70945
Haematinics	7	45.25	71.90	57.9500	10.02754
Pain Medication	17	40.61	69.83	56.6565	9.94186

As seen from Table 1, the appetite stimulant package inserts scored a mean lexical density of 59.8809 (SD= 7.17752). The highest mean lexical density score was recorded for the PILs that accompanied over-the-counter cough medicines (Mean= 64.9522, SD= 8.92367). At 51.9467 (SD= 7.52005), the PILs accompanying the dewormers scored the lowest mean lexical density. Perhaps this can be explained by the fact some PILs in the dewormer group scored as low as 37.97 of lexical density. Meanwhile, the cold and flu medicines information leaflets recorded the widest variations in their lexical density scores with a standard deviation of 12.59833 for a mean of 61.0314.

Because lexical items are the information components of a sentence, a text with higher lexical density has more information, and therefore carries more meaning, than one with lower lexical density (Johansson 2008). The concept of lexical density is related to the notion that the greater the information load of a text, the greater that text's demand on working memory, and therefore, the more difficult that text is to understand and recall. On the other hand, the lower the lexical item proportion of the text, the lower the lexical density, the lower the text's demand on working memory, and the easier the text is to understand and recall (Ramadhan et al. 2017). Spoken text has lower lexical density relative to written text (Ure 1971). This suggests that written text is generally more difficult to process and recall than spoken text.

According to a categorization by Sholichatun (2011), there are three levels of lexical density for written texts: high (60-70%), medium (50-60%), and low (40-50%). Guillén Galve (1998) found that while lexical density of everyday written text might average 40%, scientific writing might have lexical densities as high as 55-75%. Against these considerations, the PILs tested generally have medium to high lexical densities. In fact, the 'Maximum' statistic shows that in every group of PILs there were those with very high lexical densities, with some in the cold and flu medicine group going as high as over 80%. According to the mean percentages recorded in Table 9, the PILs for the appetite stimulants, the cold and flu medicines, and the cough preparations have high lexical densities mostly. This means that they generally will offer the greatest processing load to working memory among the PILs tested. The implication is that they will be generally difficult to understand and recall. PILs in the other groups should present medium challenges to the average reader.

Generally, though, it appears that all texts tested in this study could present the average reader with significant cognitive load as they try to process the information offered on the package inserts. This finding seems to support the results from the readability formulas that indicated that the PILs were generally above the reading and comprehension abilities of the average patient. The generally high lexical densities could be construed as semantic noise. This is because the generally high cognitive loads they require for processing could potentially defeat the communicative transaction between the pharmaceutical providers (senders) and the majority of readers (receivers). Perhaps the pharmaceutical companies have generally failed to encode their information in forms that are considerate of many in their target audience. It should be noted that even individuals with higher reading levels have been found to prefer information that is written at lower levels as it is easier to comprehend and takes less time to read (Wilson 2008). Therefore, encoding package insert information at an appropriate lexical density (more orality) should not present advanced readers with much cognitive difficulty. However, encoding medicine leaflet information at inappropriate lexical densities (in this case too little orality) could be disadvantageous to average readers.

Comparison of Lexical Density of PILs of the Seven Groups of OTC Medicines

Effort was made to test for statistically significant differences among lexical density scores for the various groups. This was done by means of the inferential statistical procedure known as Analysis of Variance (ANOVA). The data sets fulfilled the assumptions required for a parametric comparison of means (see Table 2).

Table 2. *Analysis of Variance of Lexical Density Scores*

		Sum of Squares	df	Mean Square	F	Sig.
lexical density	Between Groups	906.385	6	151.064	1.859	0.103
	Within Groups	4874.771	60	81.246		
	Total	5781.157	66			

At the $p<0.05$ level, there were no significant differences in the lexical scores among the seven groups of PILs [$F(6, 60)= 1.859$, $p= 0.103$] (see Table 2 above). This result means that, statistically speaking, each PIL should present the average reader with about the same processing challenge as any of the other PILs tested.

The lexical densities of the PILs tested in this study are generally high. The potential implication of these lapses in communication is that patients may not fully benefit from information regarding their medications that could have been useful.

Syntactic Complexity of the PILs of the Seven Groups of OTC Medicines

Grammatical complexity or syntactic complexity is a measure of how complex or dense the grammar used in a piece of text is. Measuring grammatical

complexity involves examining the set of strings in a grammatical structure. In this study, grammatical complexity was approached from one of the definitions of 'complexity' distilled from the literature by Pallotti (2015, p. 2); this definition is concerned with "processing costs" or difficulties that are "associated with linguistic structures". The syntactic complexity measure (of the Coh-Metrix facility) that was used in this study is considered to be directly or indirectly related to the processing difficulty a text presents to a reader (Dowell et al. 2016; McNamara et al. 2014). In this work, the indices of syntactic complexity measured were *left embeddedness (the number of words before the main verb in a sentence)* (denoted for brevity as SYNNLE), and *number of modifiers per noun phrase* (denoted for brevity as SYNNP). These are sufficient indicators of text complexity and therefore difficulty because "[t]he syntax in text tends to be easier to process when there are shorter sentences, few words before the main verb of the main clause, and few words per noun-phrase" (McNamara et al. 2014, p. 70).

The syntactic complexity scores reported are interpreted according to normative scores (hereafter sometimes referred to as 'norms') published in the Appendix B of the book "Automated evaluation of text and discourse with Coh-Metrix" (McNamara et al. 2014). Apart from descriptive indices, the norms published in the Appendix B of the aforementioned book provide normative values that can be used to compare other texts in the corresponding genre. Because PILs are published in the field of medical field, they fall under the science genre. Therefore, the syntactic complexity scores for these PILs were rightly compared to the norms in the science genre in order to arrive at conclusions on their suitable grade levels. Tables 12 to 18 present the summarised syntactic complexity scores of the various groups of PILs.

Table 3. *Quantitative Description of the Syntactic complexity of Appetite Stimulant PILs*

	N	Minimum	Maximum	Mean	Std. Deviation
left embeddedness; words before main verb	11	0.565	4.667	2.199	1.398
number of modifiers per noun phrase	11	0.745	1.087	0.900	0.105

As Table 3 shows, the mean SYNNLE for the appetite stimulants PILs was 2.199 (SD=1.398). This score maps unto approximately Grades 1 to 3 on the norms table. The SYNNP score (Mean= 0.900, SD= 0.105), however, placed the texts at approximately Grades 6 to 9. It appears that the two indices vary widely on the grade levels for which the appetite stimulant PILs were suitable. Generally, though, it appears that SYNNP placed the texts closer to the readability levels indicated by the SMOG and Flesch-Kincaid indices.

The scores mean that the texts in the appetite stimulant PILs generally did not have many words before main verbs in their sentences. This should present readers with lower processing challenges. However, this could be negated by the relatively high number of modifiers per noun phrase. Still, at Grades 6 to 9, the texts should be suitable for the average formally educated adult.

Table 4. *Quantitative Description of Syntactic Complexity of Cold and Flu Medicine PILs*

	N	Minimum	Maximum	Mean	Std. Deviation
left embeddedness; words before main verb	7	0.909	3.655	2.032	0.920
number of modifiers per noun phrase	7	0.717	1.109	0.964	0.133

SYNNLE for the package leaflets from cold and flu medicines was 2.032 (SD= 0.920) (see Table 4). This placed the texts at Grades 1 to 2 on the norms table. SYNNP was 0.964 (SD= 0.133), placing the texts at Grades 10 to 11. Again, there appears to be a wide variation between the two indices concerning text's grade-level placement. The relatively low SNNLE should make the texts easier to process for the average adult reader. However, the relatively high SYNNP places the text about a grade or two above the 8th-Grade recommended reading difficulty levels (Cutts 2013).

Table 5. *Quantitative Description of Syntactic Complexity of Cough Preparation PILs*

	N	Minimum	Maximum	Mean	Std. Deviation
left embeddedness; words before maein verb	9	0.605	2.733	1.743	0.786
number of modifiers per noun phrase	9	0.667	1.426	0.876	0.248

Table 5 shows that the mean SYNNLE for the cough preparation packet inserts was 1.743 (SD= 0.786). This suggests that the text should be easy for most readers to process, the text being placed at the pre-school to Grade 1 level. SYNNP (Mean= 0.876, SD= 0.248), on the other hand, suggests that the texts from these package inserts are similar to typical science texts for Grades 5 to 8 on average.

The mean lexical density of the cough preparation leaflets (see Table 2) showed that these PILs were highly informative or descriptive. They would therefore require high cognitive processing for understanding and recall. However, such cognitive load challenges may be tempered by the relatively low average number of words before main verbs and appropriate number of modifiers per noun phrase.

Table 6. *Quantitative Description of Syntactic Complexity of Dewormer PILs*

	N	Minimum	Maximum	Mean	Std. Deviation
left embeddedness; words before main verb	9	1.212	6.529	3.490	1.771
number of modifiers per noun phrase	9	0.867	1.104	0.992	0.070

Dewormers PILs scored the lowest mean lexical density (see Table 2). This means that, among the groups of package leaflets studied, they generally offered

the least challenge to cognitive processing. Still, the readability indices suggested that they were very difficult to read. According to the norms table, however, the dewormer PILs were, on average, similar to Grades 5 to 6 science texts in terms of the mean number of words before main verbs (Mean= 3.490, SD= 1.771) (see Table 6). If it is assumed that the average reader has the cognitive processing capacity of an 8th Grader, then the texts from the dewormers should present easy processing costs to the average reader. In terms of SYNNP (Mean= 0.992, SD= 0.070), the dewormer texts were generally placed at Grade 11 and above. This may too high for an average reader to process comfortably.

Table 7. *Quantitative Description of Syntactic Complexity of GIT Reflux Reliever PILs*

	N	Minimum	Maximum	Mean	Std. Deviation
left embeddedness; words before main verb	8	1.097	4.571	2.618	1.128
number of modifiers per noun phrase	8	0.807	1.022	0.917	0.065

As can be seen in Table 16, SYNNLE for the packet inserts from the GIT reflux reliever medicines was 2.618 (SD= 1.128). On the norms table, this placed the texts at Grades 2 to 3. This means that those PILs should present about as much cognitive load as science texts for Grades 2 to 3. SYNNP, however, placed the texts between Grades 8 and 9 (Mean= 0.917, SD= 0.065), or just within the abilities of the average reader according to readability recommendations (Cutts 2013). The GIT reflux reliever PILs should therefore be easy to process by the average reader. In contrast, the readability formulas suggested that these texts were very difficult to read and suited for university level readers, while the mean lexical density indicated that they should present medium processing difficulties (Sholichatun 2011).

Table 8. *Quantitative Description of Syntactic Complexity of Haematinics PILs*

	N	Minimum	Maximum	Mean	Std. Deviation
left embeddedness; words before main verb	7	1.520	3.591	2.871	0.725
number of modifiers per noun phrase	7	0.695	1.149	0.910	0.157

Per the norms table, the haematinic PILs have the left embeddedness (SYNNLE) typical of Grades 3 to 4 science texts (Mean= 2.871, SD= 0.725) (see Table 8). However, the norms suggest that the haematinics PILs generally have number of modifiers per noun phrase (SYNNP) that is typical of 8th to 9th Grade science texts. In either case, the syntactic complexity of the texts generally should be easy to process by the average reader, that is, if it assumed that the average reader has the aptitude of an 8th-Grader.

In terms of lexical density, the heamatinics PILs generally scored high enough to be typical of academic/scientific writing (see Table 1). The readability consensus concerning this group of PILs was that they were very difficult to read.

Nevertheless, the syntactic complexity indices appear to show that, structure-wise, these PILs are suited to cognitive facilities of basic school level readers.

Table 9. *Quantitative Description of Syntactic Complexity of Pain Medicine PILs*

	N	Minimum	Maximum	Mean	Std. Deviation
left embeddedness; words before main verb	16	0.600	4.731	2.497	1.391
number of modifiers per noun phrase	16	0.798	1.298	1.067	0.139

Table 9 shows that, on average, pain medicine PILs had 2.497 words before a main verb in typical sentences. That is about three words before a main verb in typical sentence. The standard deviation of 1.391 suggests that sentences may have deviated from the typical words-before-main-verb count by one word or so. Referring to the Coh-Metrix norms table, the mean figure placed the pain medicine PILs at the level of Grade 1 at least, and Grade 2 at most. However, the *Maximum* statistic suggests that some of the PILs in this group had syntactic complexity typical of science texts for 9^{th} to 10^{th} Grade. On the other hand, SYNNP placed the texts of the PILs at Grade 11 and beyond (Mean= 1.067, SD= 0.139).

The pain medication PILs were on average suitable for Grade 14 (university level) according to the readability indices. Concerning lexical density, they were found to be quite dense (see Table 2) and therefore would generally present medium to high processing loads to the average reader. The SYNNP score seems to agree with the processing load suggested by the lexical density score. However, these difficulties are not further enhanced by a large average number of words before main verb.

It appears that, in terms of syntactic complexity, the texts of the PILs were generally within the cognitive processing abilities of basic school readers. This would suggest that in terms of structure, the PILs (or more specifically, the portions of the PILs tested) generally would not present high cognitive costs to readers. Table 9 presents a comparison of the syntactic complexity scores for the seven groups of PILs tested.

Table 10. *Comparison of Syntactic Complexity of 7 Groups of PILs*

		Sum of Squares	df	Mean Square	F	Sig.
SYNNLE	Between Groups	17.578	6	2.930	1.836	0.107
	Within Groups	95.730	60	1.595		
	Total	113.308	66			
SYNNP	Between Groups	0.327	6	0.055	2.697	0.022
	Within Groups	1.214	60	0.020		
	Total	1.542	66			

At the $p< 0.05$ level, there were no statistically significant differences between seven groups of PILs in terms of the mean number of words before main verb in a sentence [$F(6, 60)= 1.836$, $p= 0.107$] (see Table 10). However, there was a statistically significant difference between some groups of PILs at the $p<0.05$ level

where number of modifiers per noun phrase was concerned; [F(6, 60)= 2.697, p= 0.022].

The result from the readability and Coh-Metrix indices indicated that patients of the PILs will face some difficulties when they are using PILs for relevant information. The researcher conducted a mini interview with twenty (20) participants on one to one basis to ascertain whether they read PILs, the level of difficulty the face and the reasons that their reading of PILs. The participants were 7 senior high school students, 9 first degree holders, 2 second degree holders and 1 MBA and 1 post diploma holders. The responses these participants were insightful in that the 12 of the participants read the PILs and the remaining 8 admitted they do not read PILs. The 12 participants who read the PILs submitted that they do that to know information about the drug's dosage, side effect, time to take and indications. Out of the 12 readers of PILs, 7 participants stated difficult terminologies as the cause of their lack of understanding of the PILs. The remaining 5 who understood the PILs were the tertiary participants whose educational level might have influence their comprehension of the text. On the other hand, the participants who did not read the PILs cited time constraints, already knowledge about the drugs and difficulty in understanding the PILs as reasons for their lack of readership of PILs. It is succinct therefore, patients read PILs and the reasons for their reading of PILs is to know the dosage, side effects, time of taken, expiry dates of drugs and many other relevant information that are captured in PILs. However, their understanding of the PILs is mostly hindered due to the technical terms that are used in the PILs by manufacturers. Moreover, one major cause of the lack of readership by those who did not read the PILs is the lack of understanding of the PILs. In the light of this, the researcher argues that the readability and Coh-Metrix scores were valid in that readers who had not acquired the required level of education (college level) found the PILs as very difficult to read and understand. Their main reasons for this was the difficult terms used in the PILs which implies that the prediction of the lexical density and grammatical density scores were reflecting the users experience with the PILs text.

Based on the Shannon and Weaver communication model, the researcher can make sense of the result in that the major that hinder effective communication between PILs writers (manufacturers) and the target readers (patients) is semantic noise. The patients did not complain about the materials, font and other mechanical variables, rather an overwhelming majority cited wordiness and one cited lengthiness as the causes of their lack of understanding of the PILs. It therefore implies that, for manufacturers to increase message fidelity of their PILs, there is the need to reconsider the wording and technical terms used in composing PILs so that patients can find them useful for their information needs when they are using drugs. This is much relevant in the Ghanaian setting in as sense that all the interviewees indicated that they do not buy drugs with prescription. This means that their major source of reliable information concerning the drug in order to avoid catastrophic occurrence is the PILs of those drugs. If the PILs are therefore not readable nor lexically and grammatically friendly to patients, the possibility of recording the same casualties that prompted the addition of PILs will be inevitable. Therefore, manufacturers of drugs should give keen attention to the readability of

their PILs in order to ensure effective health communication with patients of common ailments studied in this research.

Conclusion and Recommendations

The findings of this study, therefore, demonstrate that deliberate effort is required in order to produce written leaflets that are suitable for their target audiences. The evidence from consumers shows that readers are most likely to be bored by the content of leaflets if the leaflets are not readable to them. The manufacturers could also inculcate the use of readability formulae and Coh-Metrix as tools to objectively test the suitability of the leaflets before circulation. The manufacturers could consider using the Plain Language Thesaurus compiled by the Centre for Disease Control and Prevention's National Centre for Health Marketing (Vanderbilt Health.com).

In sum, health is a matter of life and death, hence any communication about health issues should be effective and understandable to audience. Readability and Coh-Metrix are vital quantitative objective tools for predicting the extent to which a text will be easy to read and understand by potential audience. Therefore, there is need to derive compliance of medical documents to the plain language recommendations especially Patient Information Leaflets. The researcher recommends a survey study on the patients readership of PILs and the possible reasons and challenges they encounter. Such a study will help to discover the usefulness of the PILs to patients and the urgency for writer of PILs to consider readability as tool to achieving effective health communication with their users. The researcher recommends further researches that will examine large health documents readability such as brochures, booklets and many other health documents.

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