UNIVERSITI TEKNOLOGI MARA

INDOOR AIR QUALITY AND ITS RELATIONSHIP WITH BUILDING DESIGN, BUILDING OPERATION, AND OCCUPANTS' BEHAVIOUR IN JOHOR PUBLIC HOSPITAL OUTPATIENT DEPARTMENTS

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ABSTRACT

Poor indoor air quality (IAQ) in healthcare settings may adversely impact occupants' well-being and promote the transmission of infectious respiratory disease. However, evidence on IAQ in hospital outpatient departments (OPDs) and its building and occupant-related factors remains scarce. This study aims to determine the relationship between building design, building operation, and occupants' behaviour with IAQ in Johor public hospital OPDs. A multistage cross-sectional study of six randomly selected Johor public hospital OPDs was conducted. In stage one, IAQ parameters, including temperature, relative humidity (RH), air velocity (AV), carbon dioxide (CO_2), total bacterial count (TBC), and total fungal count (TFC) were measured. In stage two, hospital records on building design and operation of selected hospital OPDs were examined. In stage three, an observation form based on the Korsavi and Montazami (2019) validated tool for measuring adaptive behaviours was used to examine occupant density, activities, and operation of building envelopes and appliances. Simple correlation, partial correlation, and linear regression analyses were then performed to examine the relationship of building design, building operation, and occupant behaviour with IAQ parameters. Based on the IAQ parameter measurements (n=384), the study results indicated that the IAQ of selected hospital OPDs complied with established standards, except for temperature, RH, and AV. In terms of building design, ventilation system design was negatively correlated with temperature, RH, AV, CO_2, TBC, and TFC, whereas the total number of appliances was positively correlated with AV. Meanwhile, the size of OPD was positively correlated with TBC and TFC. With regards to occupant behaviour, occupant density was positively correlated with temperature, RH, AV, CO_2, TBC, and TFC. Meanwhile, based on the observation of selected hospital OPD occupants (n=151), occupants' activities including slow walking and brisk walking were positively correlated with temperature, AV, CO_2, TBC, and TFC, whereas occupants' opening of windows and doors was positively correlated with temperature and AV but negatively correlated with CO_2, TBC, and TFC. Finally, turning on fans was positively correlated with AV but negatively correlated with TBC, whereas turning on the air conditioner was positively correlated with CO_2. On the whole, ventilation system design and occupants' operation of doors and windows contributed the most to variation in IAQ parameters. The study findings suggest that the IAQ of hospital OPDs are significantly related to building design and occupant behaviour factors, including ventilation system design, number of appliances, OPD size, occupant density, occupant activities, and occupants' operation of building envelopes and appliances. Consequently, multidisciplinary and multipronged strategies considering these important building and occupant-related determinants are deemed viable for the future control and improvement of hospital IAQ.

Keywords: Indoor air quality, building design, building operation, occupant behaviour, occupant factor, healthcare, hospital

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TABLE OF CONTENTS

		Page
CONFIRMATION BY PANEL OF EXAMINERS		**ii**
AUTHOR'S DECLARATION		**iii**
ABSTRACT		**iv**
ACKNOWLEDGEMENT		**v**
TABLE OF CONTENTS		**vi**
LIST OF TABLES		**xii**
LIST OF FIGURES		**xv**
LIST OF SYMBOLS		**xvi**
LIST OF ABBREVIATIONS		**xvii**
CHAPTER ONE INTRODUCTION		**1**
1.1	Research Background	1
1.2	Problem Statement	3
1.3	Research Objectives	5
1.4	Research Questions	5
1.5	Research Hypothesis	6
1.6	Significance of Study	6
1.7	Scope of the Study	6
CHAPTER TWO LITERATURE REVIEW		**8**
2.1	Introduction	8
2.2	Literature Search	8
2.3	Malaysian Healthcare System	8
	2.3.1 Public Health and Primary Healthcare	10
	2.3.2 Secondary and Tertiary Healthcare	12
2.4	Indoor Air Quality (IAQ)	15
	2.4.1 Introduction to IAQ	15
	2.4.2 Parameters of IAQ	16
	2.4.3 Acceptable Range for IAQ Parameters	18

CHAPTER ONE
INTRODUCTION

1.1 Research Background

Over the past few decades, indoor air quality (IAQ) has received increasing attention from the international scientific community, political stakeholders, and environmental health practitioners. IAQ is a term that pertains to the air quality within and surrounding buildings and structures, primarily affecting the health and comfort of occupants (United States Environmental Protection Agency, 2021b). The IAQ of a building is determined by its specific physical parameters (i.e. temperature, relative humidity (RH), and air velocity (AV)), chemical contaminants (i.e. carbon monoxide, formaldehyde, ozone, respirable particulates, and total volatile organic compounds (TVOC)), biological contaminants (i.e. total bacterial count (TBC) and total fungal count (TFC)), and ventilation performance indicator values (i.e. carbon dioxide (CO_2)) (Department of Occupational Safety and Health, 2010). IAQ may be hampered by various conditions, including suboptimal air temperature, low or high humidity, inadequate air movement, insufficient ventilation, and the presence of chemical contaminants and bioaerosols such as bacteria, viruses, or fungi (Department of Occupational Safety and Health, 2021b).

Poor IAQ is a significant public health problem, as it can affect a person's health and well-being in domestic and industrial buildings (Abbasi et al., 2019; Mujan et al., 2019). Building with poor IAQ is known to cause various short and long-term health issues to its occupants, including allergic reactions, respiratory problems, eye irritation, sinusitis, bronchitis, and pneumonia (Department of Occupational Safety and Health, 2021b; Joshi, 2008; Tran et al., 2020). Additionally, building-related illness (BRI) and sick building syndrome (SBS) occurrences are not uncommon issues, owing to the deteriorating IAQ of the poorly maintained buildings (Nag, 2018). In fact, indoor air pollution is now widely recognized as having a more significant potential impact on public health than most outdoor air pollution, as some of the health problems it causes can be fatal, such as cancers and cardiovascular diseases (Manisalidis et al., 2020; World Health Organization, 2022). Studies have shown that poor IAQ in the workplace can significantly impact workers' mental health, physical health, and performance,