

UNIVERSITI TEKNOLOGI MARA

**THE DEVELOPMENT OF
RECOMMENDED PROTOCOLS TO
PREVENT AND CONTROL
INDUSTRIAL OTOTOXICITY RISK
ARISING FROM ORGANIC
SOLVENTS EXPOSURE**

**AINUL NAQUEAH BINTI ZAINAL
ABIDIN**

Thesis submitted in fulfilment
of the requirements for the degree of
Doctor of Philosophy
(Environmental Health and Safety)

Faculty of Health Science

July 2023

ABSTRACT

Occupational hearing loss is traditionally thought to be caused solely by exposure to loud noise. However, the present global incidence of hearing loss cannot be attributed just to exposure to loud noise; chemicals have a significant role as well. The likelihood of a correlation between organic solvent exposure and hearing loss cannot be ruled out. The critical gap is that there are no studies on government policies that link chemical ototoxicity to occupational hearing loss. Therefore, until revised standards are established, a prudent way to incorporate this gap and challenge is to develop protocols for employers and safety management teams to prevent and control ototoxicity risk arising from organic solvents. This study aims to develop industrial ototoxicity recommended protocols to prevent and control ototoxicity risks arising from organic solvent exposure. This study employed Design and Development Research (DDR) approach. Based on the approach, the study was divided into three (3) phases. In the first phase, a Needs Analysis survey was conducted on 195 workers in paint and coating companies to identify their awareness level of the organic solvents' ototoxicity risk and the needs of the protocols. The data were analysed using descriptive statistics using Statistical Package for the Social Science (SPSS) software. The Needs Analysis was strengthened by conducting an interview session with three (3) experts where the data was analysed using thematic analysis. The outcome of this phase indicated that there is a strong need for the Recommended Protocols to prevent and control the risk of hearing problems arising from organic solvents to be developed. In the second phase, two (2) reference models and literature were analysed to design the main components and the elements of the recommended protocols. The components and elements were validated by eleven (11) experts based on their consensus through Fuzzy Delphi Method (FDM). The outcome of this phase results in the establishment of the Industrial Ototoxicity Control (IOC) Recommended Protocols. The third phase was the usability evaluation by six (6) experts from the paint and coating industry via a semi-structured interview method where the data was analysed using thematic analysis. The results showed that all experts involved in this phase agreed that the main components, elements, and the sequence of priority of the Recommended Protocols are appropriate and practicable to be employed. To conclude, this study has significantly succeeded in establishing validated Recommended Protocols to provide strategies for preventing and controlling industrial ototoxicity risk arising from organic solvent exposure. It should be noted that this empirical research has successfully achieved all specific objectives for each phase of the research. The outcome of this research provides great benefits to the education field in further catalysing occupational ototoxicity studies in Malaysia. Moreover, the Recommended Protocols promote a proactive approach to dealing with ototoxic hazards in the industry.

ACKNOWLEDGEMENT

Firstly, I wish to thank Allah S.W.T for giving me the opportunity to embark on my Phd and for completing this long and challenging journey successfully. My gratitude and thanks go to my supervisors, Assoc. Prof. Ts. Dr. Mohd Shukri bin Mohd Aris, Assoc. Prof. Dr. Ailin binti Razali and Assoc. Prof. Dr. Norazura binti Ismail for their valuable guidance, and continuous support.

My appreciation goes to all participants who took part voluntarily and gave their full commitment despite their busy work schedules. Their intellectual ideas guided me to innovate Industrial Ototoxicity Control Recommended Protocols.

Finally, this thesis is dedicated to the loving memory of my very dear late mother,
and my lovely father, for their
prayers and endless support. Special thanks to my husband,
and my beautiful daughters, and
for their patience and for being my strength of pillar. This piece of
victory is dedicated to all of you. Alhamdulillah.

TABLE OF CONTENTS

CONFIRMATION BY PANEL OF EXAMINERS

AUTHOR'S DECLARATION

ABSTRACT

ACKNOWLEDGEMENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

LIST OF ABBREVIATIONS

CHAPTER ONE: INTRODUCTION

- 1.1 Research Background
- 1.2 Problem Statement
- 1.3 Objective
- 1.4 Research questions
- 1.5 Significant of study
- 1.6 Limitation of study
- 1.7 Definition of terms
 - 1.7.1 Protocols
 - 1.7.2 Ototoxicity
 - 1.7.3 Industrial ototoxicity
 - 1.7.4 Organic solvent
- 1.8 Summary

CHAPTER TWO: LITERATURE REVIEW

- 2.1 Introduction
- 2.2 Mechanism of Hearing and Ototoxicity
- 2.3 Solvents in Paint and Coating Industry
- 2.4 Ototoxicity Due to Solvent Exposure

2.4.1	Ototoxicity of Styrene Exposure	23
2.4.2	Ototoxicity of Toluene Exposure	26
2.4.3	Ototoxicity of Xylene Exposure	28
2.4.4	Ototoxicity of Ethylbenzene Exposure	30
2.4.5	Ototoxicity of Solvents Mixture Exposure in Paint & Coating Industry	31
2.4.6	Ototoxicity of Solvents Mixture Exposure in Other Industry	33
2.5	Synergistic and Additive Effects of Noise and Solvent	35
2.6	Existing Occupational Ototoxicity Prevention, Management, and Intervention	37
2.6.1	Exposure-based Approach	37
2.6.2	Knowledge-based Approach	40
2.6.3	Clinical-Based Approach	42
2.7	Theoretical Framework of Recommended Protocols Development	43
2.7.1	Katz&Kahn Theory 1978	44
2.7.2	PDCA Model (Plan-Do-Check-Act)	46
2.8	Design & Development Research	50
2.9	McKillip, 1989 Needs Analysis Model	57
2.10	Kirkpatrick' s Model	61
2.11	Delphi Method	64
2.12	Fuzzy Delphi Method (FDM)	69
CHAPTER THREE: RESEARCH METHODOLOGY		74
3.1	Introduction	74
3.2	Research Framework	75
3.3	Phase 1: Needs Analysis	77
3.3.1	Research Design	78
3.3.2	Phase 1 (Part A): Survey	80
3.3.3	Phase 1 (PartB): Interview	91
3.3.4	Research Matrix for Need Analysis Phase	97
3.4	Phase 2: Design and Development Phase	100
3.4.1	Research Design	100