CB(1)1167/12-13(01)

Health Effects of Transportation Noise in Hong Kong: Findings of a Large Scale Survey

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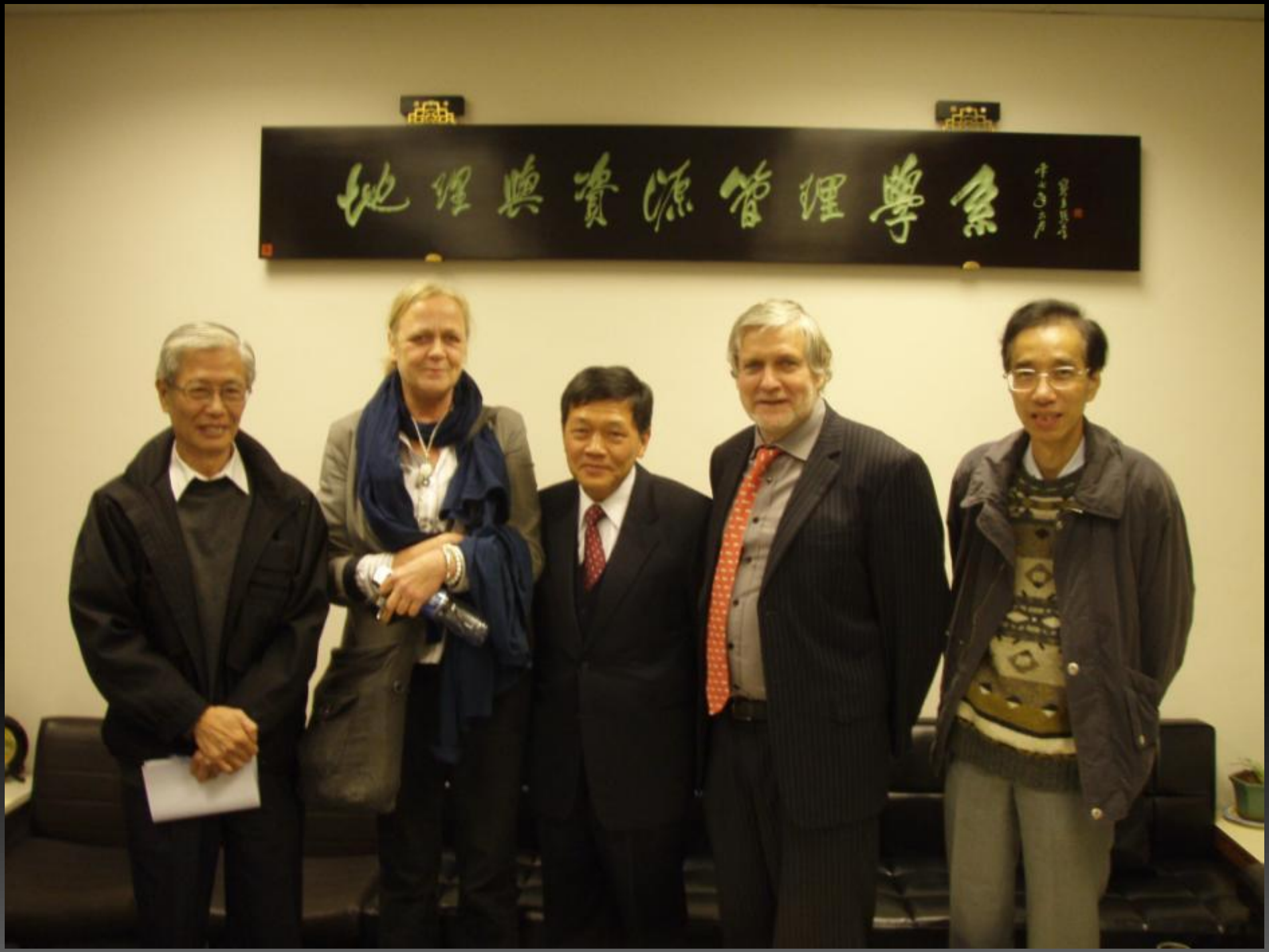
The Chinese University of Hong Kong

Presentation to LegCo Panel on Environmental Affairs
31 May 2013

Health Effects of Transportation Noise in Hong Kong Study

- Commissioned by HK EPD
- Importance …. Hong Kong is unique
  - Compact and dense city
  - Possible cultural difference
- First city-wide large scale study in Asia using internationally accepted method and state-of-art noise mapping technology


地理與資源管理學系

Health Effects of Transportation Noise in Hong Kong Study

- Study Team
  - Lam Kin Che, CUHK (GRM, CUHK)
    - Environmental noise & project leader
  - Lex Brown, Griffith University (Australia)
    - Environmental noise, survey instrument, annoyance
  - Wong Tze Wai, CUHK (Public Health, CUHK)
    - Medical practitioner & noise-health effects
  - Irene van Kamp, Nat'l Institute of Public Health (Netherlands)
    - Epidemiology, public health & sleep disturbance
  - Chan Ying Keung, CUHK (Sociology, CUHK)
    - Statistician, social surveys

Objectives

- To review the non-auditory health effects, namely annoyance, sleep disturbance and cardiovascular diseases, based on the literature available from the WHO, EU and USA and other published scientific papers
- To look into the applicability and relevance of overseas results to the Hong Kong situation
- To study the annoyance effects due to transportation noise in Hong Kong, with the help of a household survey and a territory-wide noise mapping conducted respectively by the Census and Statistics Department (C&SD) and the Environmental Protection Department (EPD)

Methodology

- **Desk-top Review** of transportation noise-related health effects

- **Self-reported Annoyance & Sleep Disturbance**: Thematic Survey of Census & Statistics Department – 10,077 randomly selected households successfully interviewed

- **Exposure to Road Traffic Noise**: city-wide noise mapping

Scope of the Study

- **Health Effects**
  - Review on annoyance, sleep disturbance & cardio-vascular diseases undertaken
  - Survey on self-reported annoyance and sleep disturbance completed
  - Self-reported cardio-vascular diseases not covered in this study

- **Noise Exposure Assessment**
  - Focused on road traffic noise only

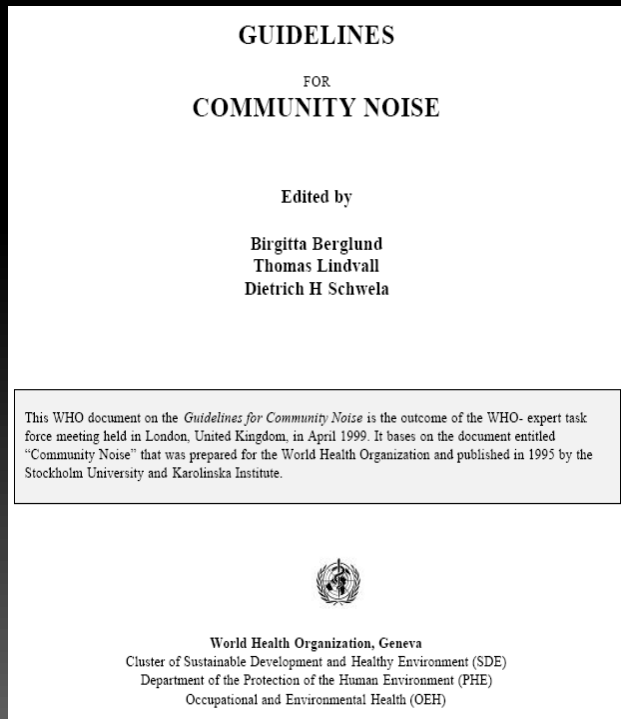
Findings

- **Desk-top Review** of transportation noise-related health effects

- **Self-reported Annoyance & Sleep Disturbance**: Thematic Survey of Census & Statistics Department

Potential Adverse Health Effects of Noise

- WHO *Guidelines for Community Noise (1999)*
  - Impact on auditory health
  - Interference with speech communication
  - Sleep disturbance
  - Performance effects
  - Annoyance
  - Cardiovascular effects



GUIDELINES

FOR

COMMUNITY NOISE

Edited by

Birgitta Berglund
Thomas Lindvall
Dietrich H Schwela

This WHO document on the *Guidelines for Community Noise* is the outcome of the WHO- expert task force meeting held in London, United Kingdom, in April 1999. It bases on the document entitled "Community Noise" that was prepared for the World Health Organization and published in 1995 by the Stockholm University and Karolinska Institute.

World Health Organization, Geneva
Cluster of Sustainable Development and Healthy Environment (SDE)
Department of the Protection of the Human Environment (PHE)
Occupational and Environmental Health (OEH)

Annoyance

- *Annoyance*
  - *"…a feeling of resentment, displeasure, discomfort, dissatisfaction, or offense when noise interferes with thoughts, feelings, or actual activities."*

- *Annoyance at High Noise Levels*
  - *"…should be considered a legitimate environmental health issue affecting the wellbeing and quality of life of the population…"*

UK Health Protection Agency, 2009

Sleep Disturbance

- Sufficient evidence
  - Biological: increase in heart rate, arousals, sleep stage changes, hormone level changes and awakening
  - Self-reported sleep disturbance => increase in medicine use, body movements and insomnia
- Limited evidence
  - Disturbed sleep causes fatigue, accidents and reduced performance
  - Clinical conditions such as cardiovascular illness, depression and other mental illness
- Vulnerable group: children, elderly, pregnant women, shift workers, chronically ill

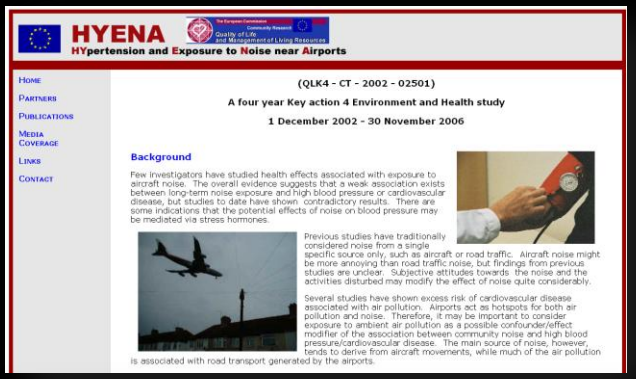
Disease and Environmental Noise

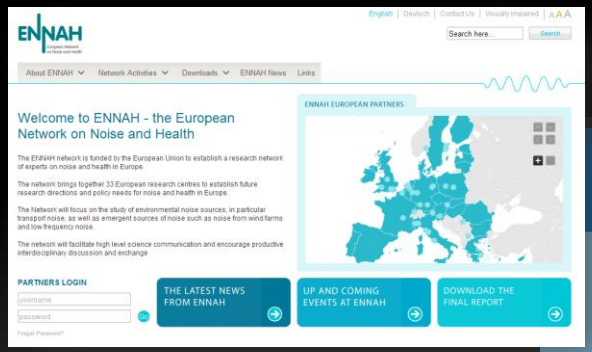
Blood pressure and heart diseases

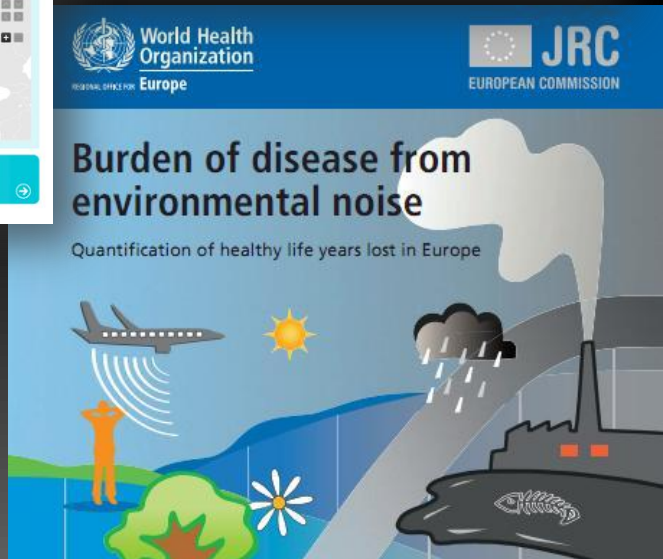
- Growing evidence that environmental noise is associated with heart diseases
- Link with heart diseases is complicated by the presence of many other “confounding factors” that are also linked to heart diseases
- Link with hypertension has more evidence, but also influenced by “confounding factors”

Noise as a Potential Health Risk

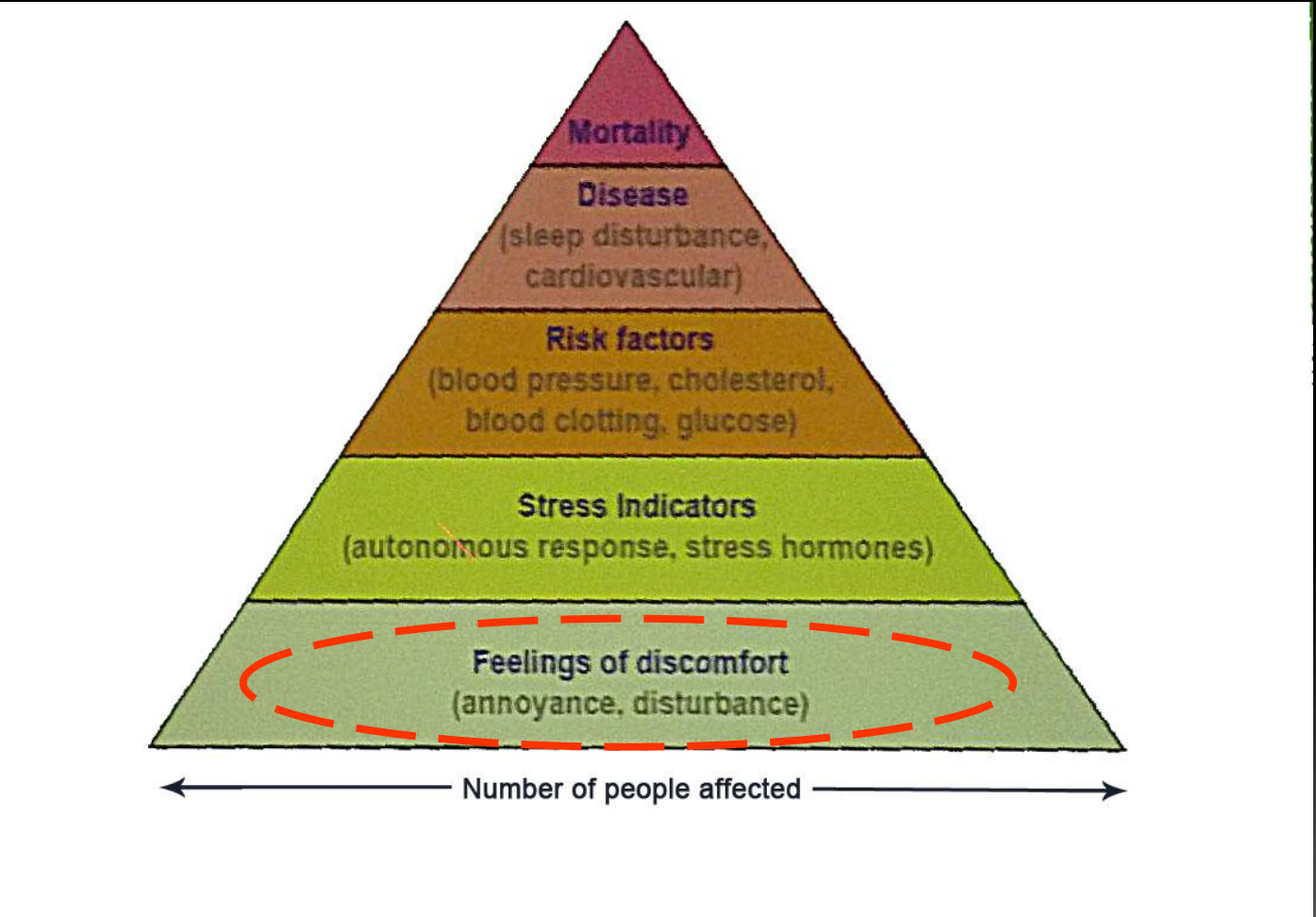
- Supported by clinical studies in last 20 years
- Ascertained by several large scale surveys
  - HYENA
  - RANCH
  - ENNAH
- Reviewed by WHO experts



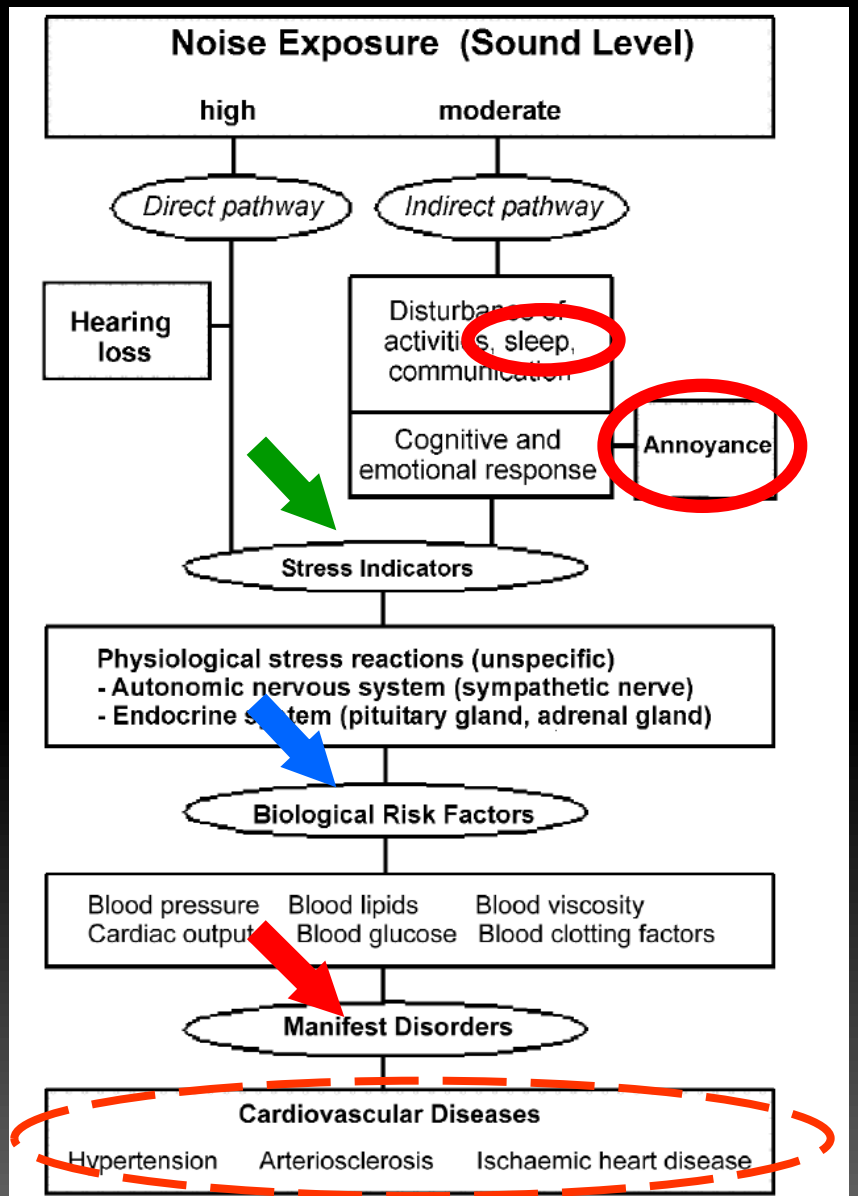




Noise – not just a feeling of discomfort



The Stress Model: Mechanism of the Noise Induced Effects *(Babisch et al, 2001)*



Further Clinical Study

Findings

- **Desk-top Review** of transportation noise-related health effects

- **Self-reported Annoyance & Sleep Disturbance**: Thematic Survey of Census & Statistics Department

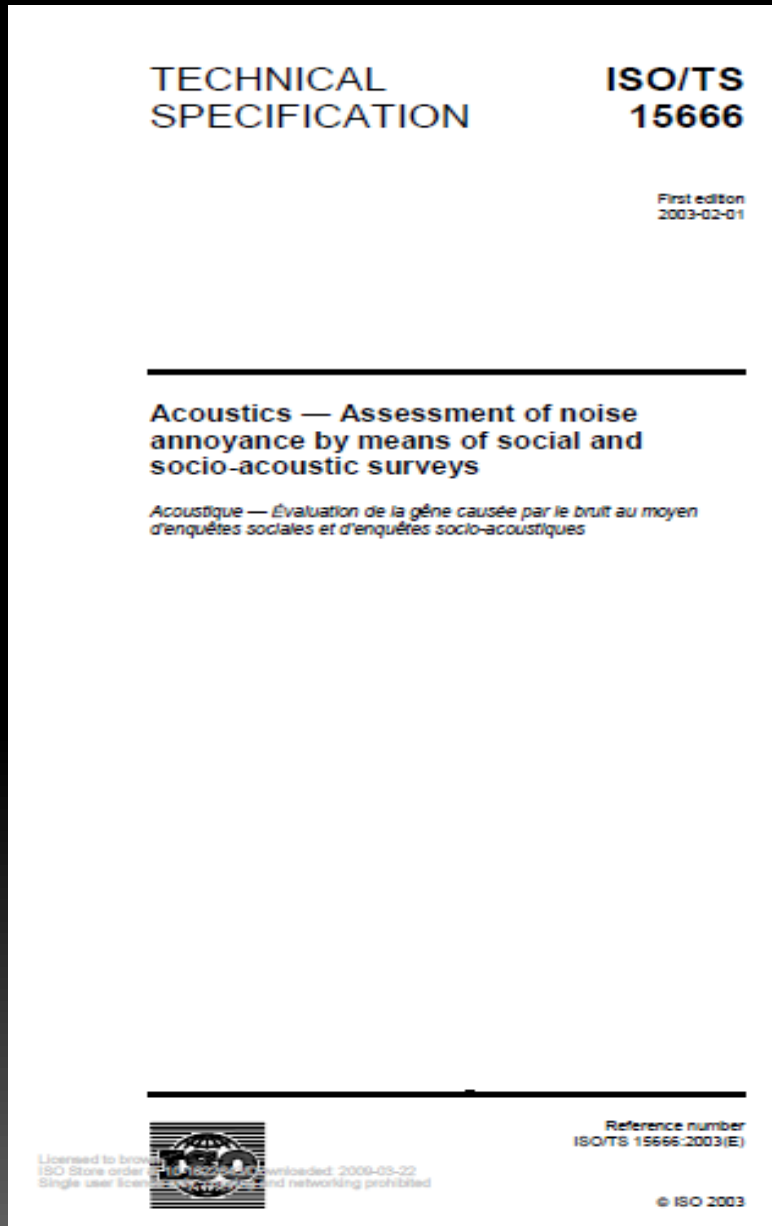
Pre-requisite to Achieve Goals

- Methodology which allows cross-country comparisons, e.g.:
  - Standardized question, wording and scales
  - Same / similar methodology as in other mega studies particularly with respect to the questions posed

- A scientific and robust approach is needed for comparison (Miedema et al., 2001)

The Survey

- 10,077 households covered
- “The question”?
  - Used the “standard” question
  - ISO 15666:2003
- How the question is posed?
  - Wording
  - Scale
    - 11-point scale
    - 5-point scale
  - Use of show card



TECHNICAL SPECIFICATION

ISO/TS 15666

First edition
2003-02-01

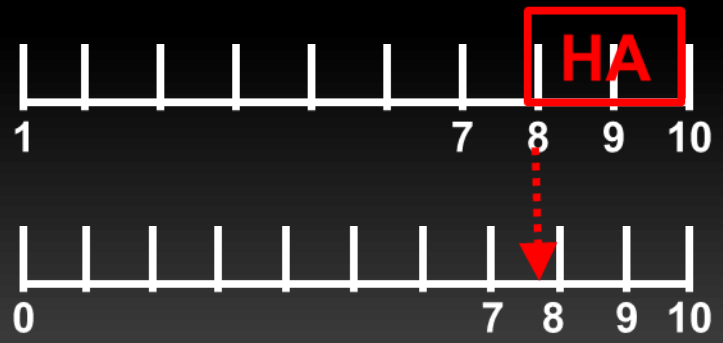
Acoustics — Assessment of noise annoyance by means of social and socio-acoustic surveys

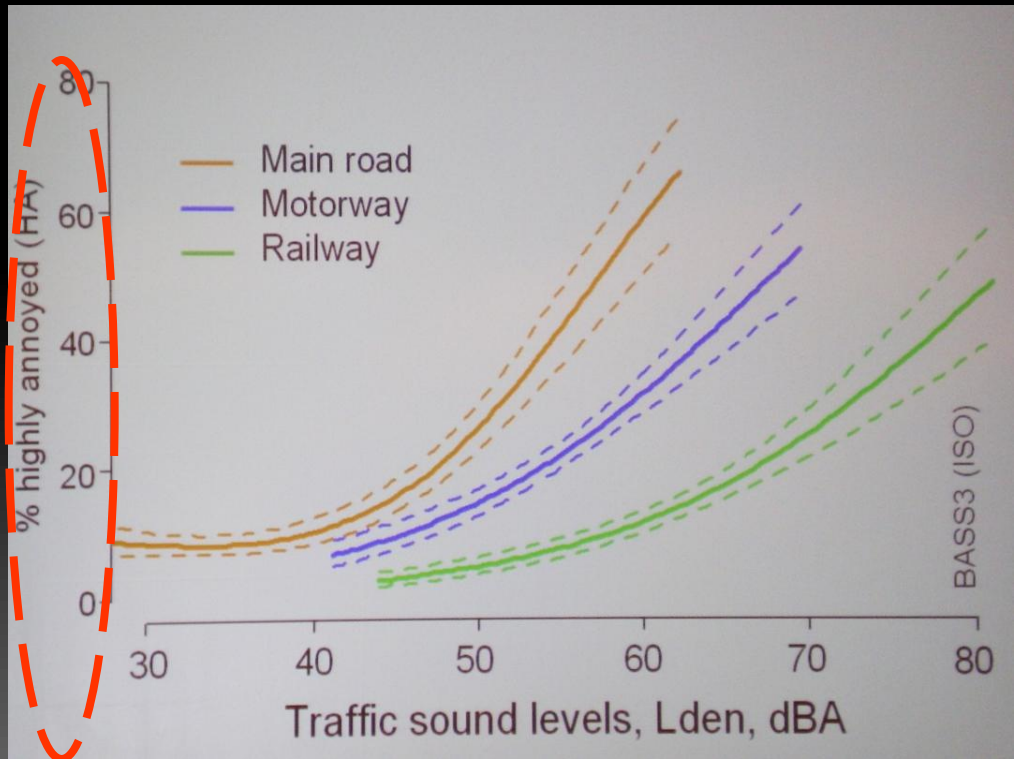
Acoustique — Évaluation de la gêne causée par le bruit au moyen d'enquêtes sociales et d'enquêtes socio-acoustiques

Reference number
ISO/TS 15666:2003(E)

The Exposure-Effect Curve

- Miedema & Oudshoorn (2001)
  - Synthesis of major studies producing exposure-effect curves
  - % Highly Annoyed
    - 8-10 on 10 pt scale





Information Obtained

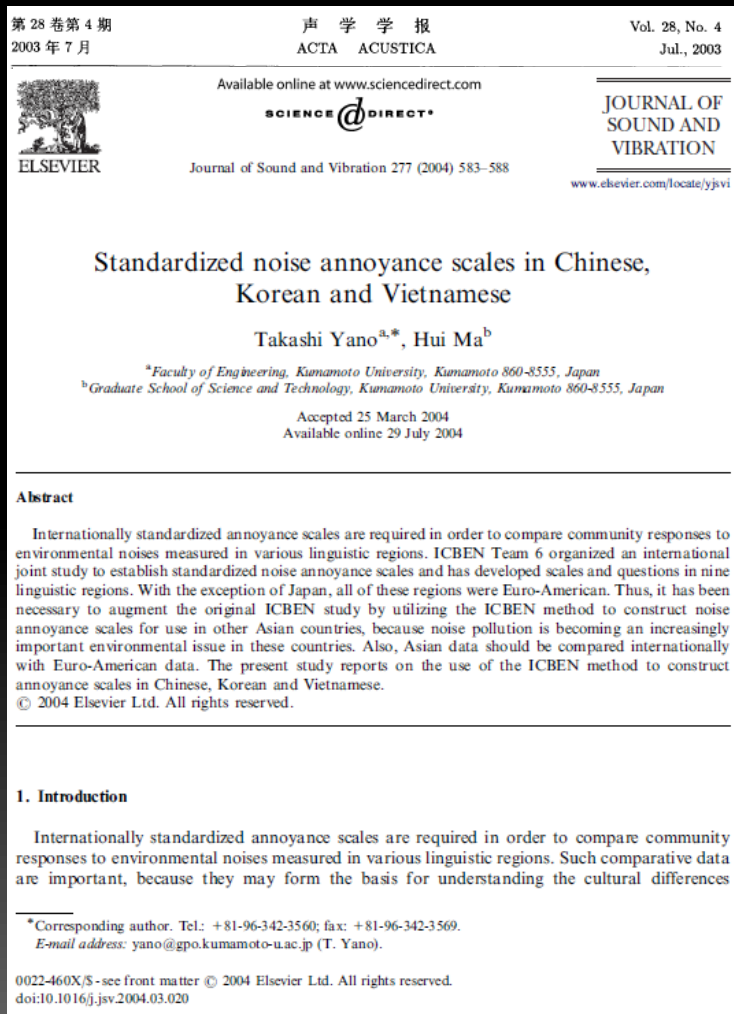
- Annoyance/ Sleep Disturbance, with respect, separately, to
  - Road traffic noise
  - Rail noise
  - Aircraft noise
  - Other noise sources
- Other information which may help explain human response:
  - Personal: noise sensitivity, health conditions, coping behavior, sleep habits
  - Exposure: window/ air-conditioning, acess to “quiet room”
  - Surrounding: satisfaction w/ neighborhood overall environment
  - Habituation: length of residence

QA/QC – Pilot Test of Questionnaire

- Two Pilot studies by CUHK Team (n >100)
  - Refinements of questions
  - Testing of Cantonese terms
  - Use of show cards

Translation and back-translation: English to Cantonese

- Need for standardization
  - From English to other languages
- How?
  - Use of words for “Annoy”, “Bother”, “Disturb”
    - Start with the Mandarin of Ma (2003) => Cantonese
    - Tried out on CUHK students in Pilot Study I
    - Back translation: E->C->E



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Standardized noise annoyance scales in Chinese, Korean and Vietnamese

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Accepted 25 March 2004
Available online 29 July 2004

Abstract

Internationally standardized annoyance scales are required in order to compare community responses to environmental noises measured in various linguistic regions. ICBEN Team 6 organized an international joint study to establish standardized noise annoyance scales and has developed scales and questions in nine linguistic regions. With the exception of Japan, all of these regions were Euro-American. Thus, it has been necessary to augment the original ICBEN study by utilizing the ICBEN method to construct noise annoyance scales for use in other Asian countries, because noise pollution is becoming an increasingly important environmental issue in these countries. Also, Asian data should be compared internationally with Euro-American data. The present study reports on the use of the ICBEN method to construct annoyance scales in Chinese, Korean and Vietnamese.

1. Introduction

Internationally standardized annoyance scales are required in order to compare community responses to environmental noises measured in various linguistic regions. Such comparative data are important, because they may form the basis for understanding the cultural differences

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QA/QC – Random Sub-sample Check of Households Interviewed

- Follow-up calls to confirm answers on selected questions, e.g.
  - Annoyance - “Did surveyor ask you about…?”
    - → Yes/ No
  - No. of rooms in household
    - → Fill in exact no.
  - Quiet room?
    - → Yes/ No

Noise Exposure Estimation

- Type of transport noise modeled
  - Road traffic
- Methodology
  - Noise mapping with respect to road traffic noise
  - Confidentiality of household addresses kept
- Noise metrics modeled
  - Road traffic – L_{DEN}, L_{night}

Technique of Noise Mapping

Input

Propagation Path

- Building footprints
- Podiums
- Barriers
- Enclosures
- Spot heights
- Contour lines
- Rivers
- Slope tops/bottoms
- Vegetation (ground absorption)

GIS

Emitters

- Railway tracks
- Road centreline
- Airport

Traffic Model

- # of vehicles
- Speed
- Vehicle weight

Processing

Noise Exposure Software

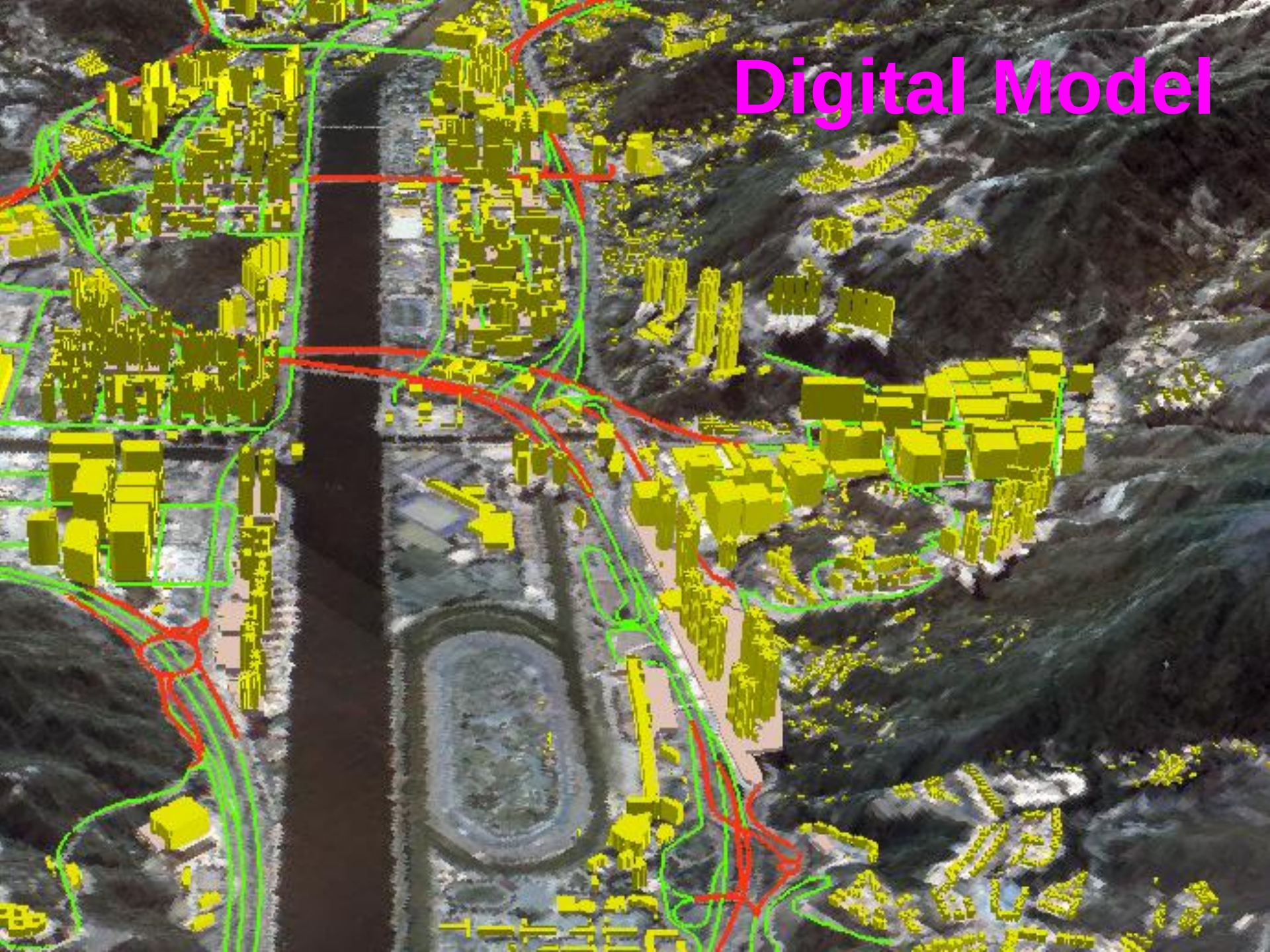
Calculates noise levels in different areas using inputs

Output

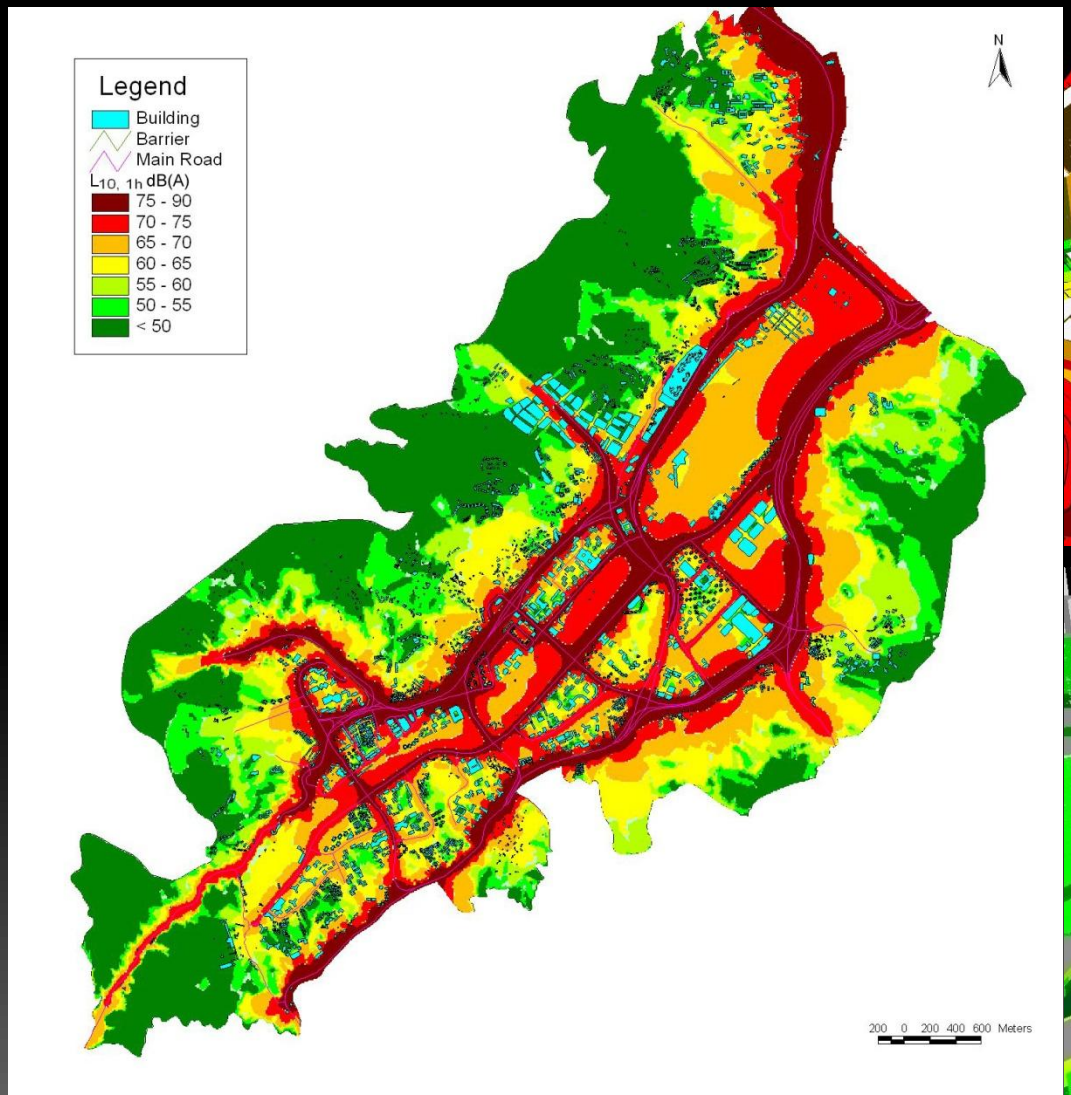
Level of exposure estimated for various areas; 3-D visualization

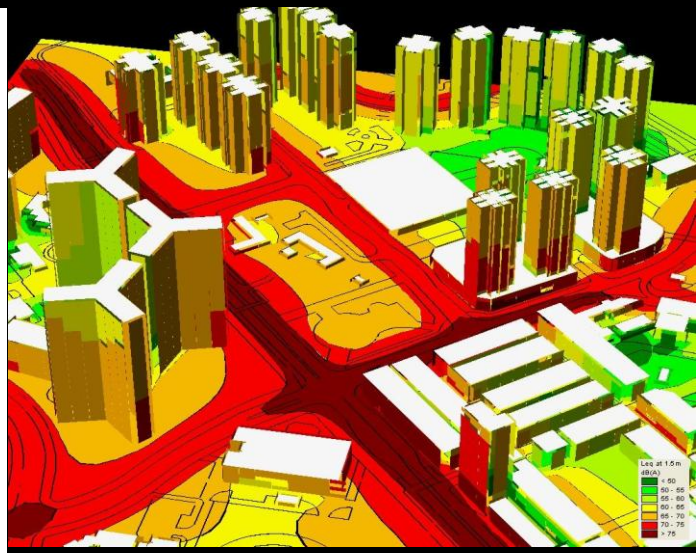
Obtain façade noise exposure of over 10,000 addresses


Real

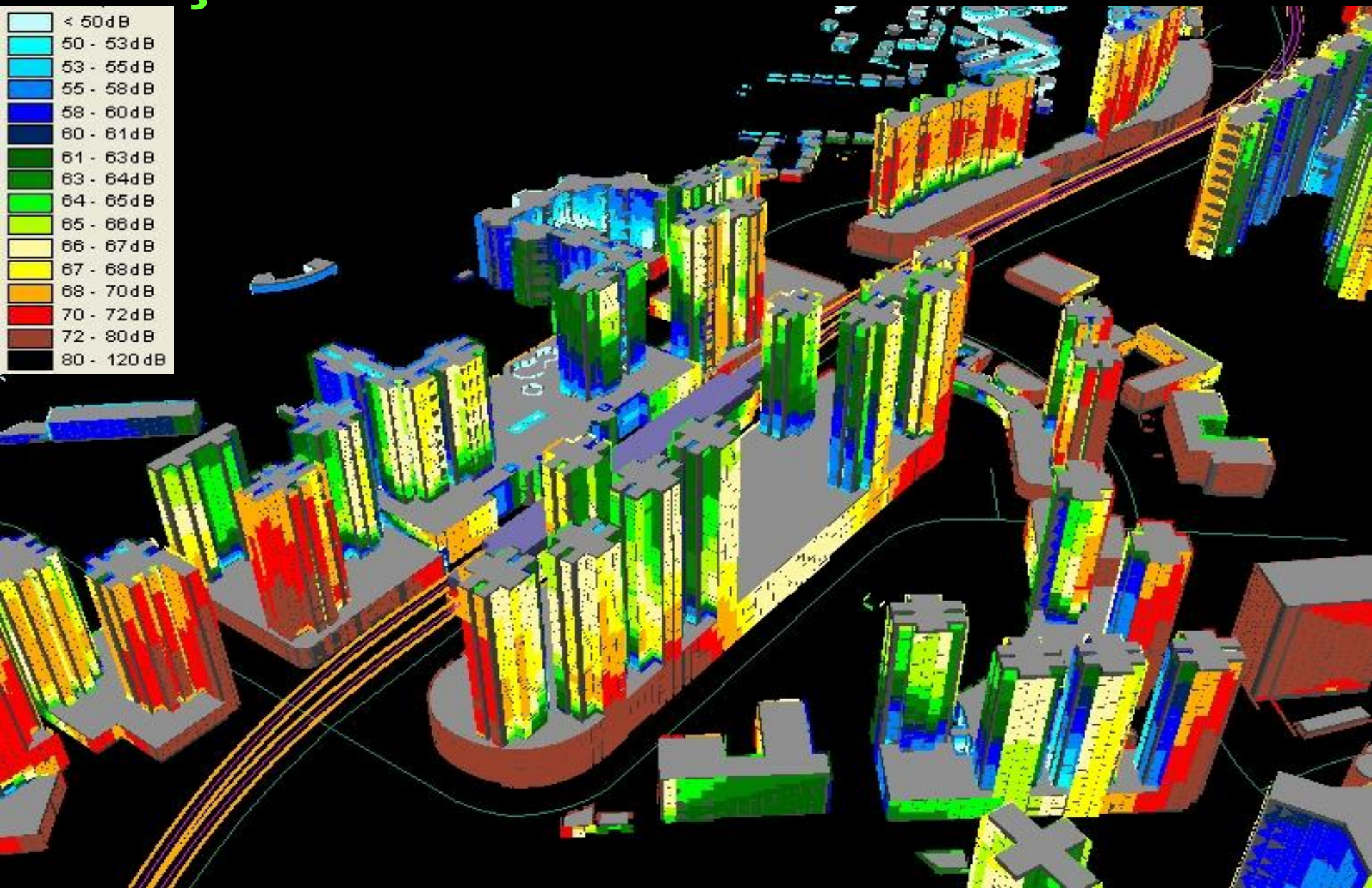

Digital Model

Example of Modeling Results





Façade Noise from Road Traffic



Key Questions

- Which noise annoys Hong Kong people most?
- How many people are affected?
- How does Hong Kong people's response compare with that of others?
- Other than noise exposure, what other factors affect annoyance and sleep disturbance?
- What are the implications of these findings?

Which Noise Annoys HK People Most?

- "Highly Annoyed" = 8 to 10 on 0 to 10 scale

Table 5.3: Percentages of respondents highly annoyed, highly annoyed at night and sleep highly disturbed by different noise sources (n=10077) (Source: This Study)

Noise Source	% Highly Annoyed (HA)	% Highly Annoyed at Night (HAN)	% Sleep Highly Disturbed (HSD)
Road traffic	7.9	**4.95**	**4.15**
MTR, trains or LRT	0.7	0.5	0.3
Aircraft	0.4	0.2	0.1
Industries/ factories/ machineries	0.5	0.2	0.1
Commercial activities	1.6	0.6	0.4
Construction/ demolition	3.4	0.2	0.2
Renovation	**10.8**	0.5	0.6
Neighbor's air conditioning	1.4	0.8	0.6
Neighbors	3.5	1.7	1.4
Playgrounds/sports ground	1.7	0.7	0.7
Outside animals	1.8	1.0	0.7

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How many people in HK are affected?

- Percent households with most exposed side of dwelling exceeding noise criterion
  - > HK Planning Standard $L_{10,1h}$ 70 dBA: 28.9%
  - > WHO L_{DEN} 65 dBA: 36.2%

- Number of adult population affected **

	% of Population	Confidence Interval (%)*	Estimated Number of Population Aged 18 or Above (in thousands)		
			2009	2010	2011
Highly Annoyed	7.9	±0.526	432.6-491.1	438.6-504.0	444.3-510.6
Highly Annoyed Night	4.95	±0.42	265.9-315.2	269.6-319.6	273.1-323.7
Highly Sleep Disturbed	4.13	±0.39	219.5-165.3	222.6-269.0	225.4-272.5

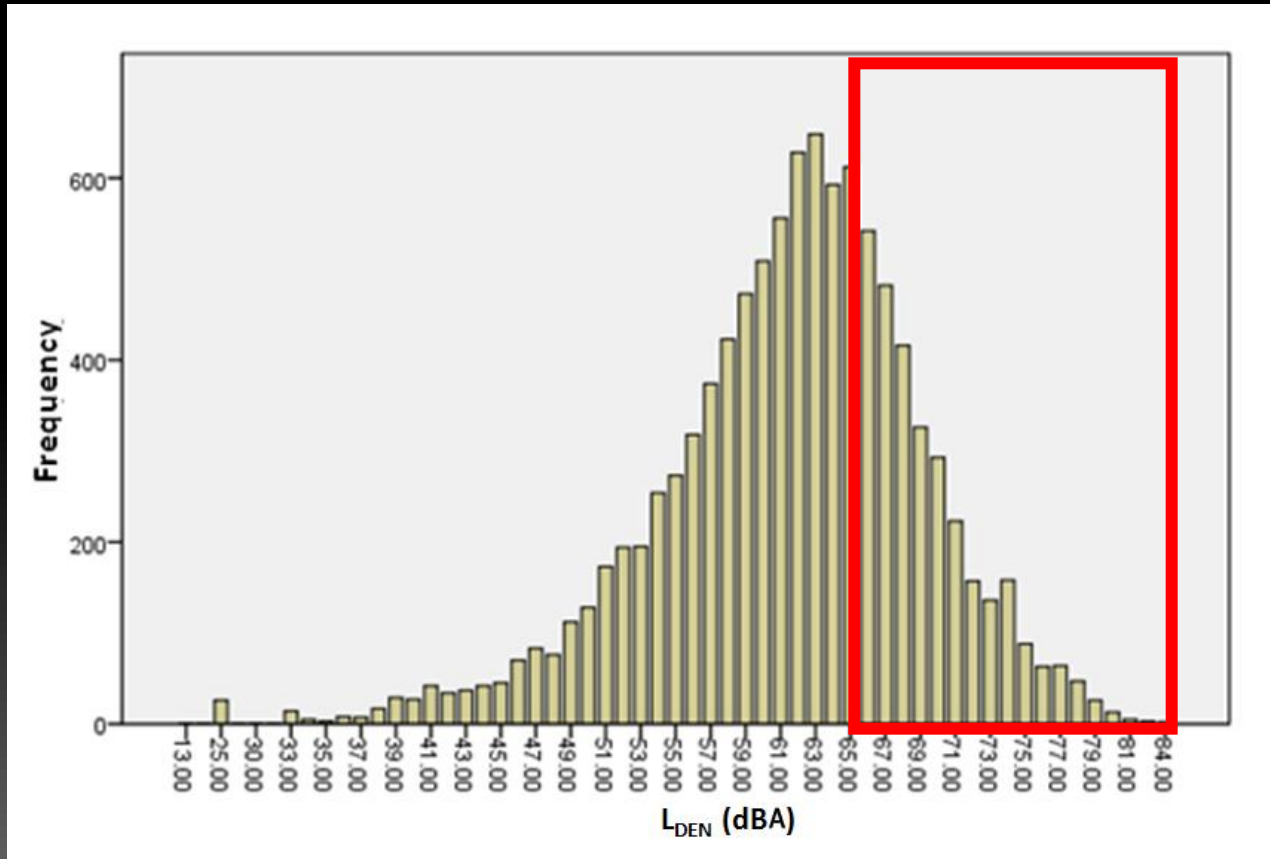
** With reference to most exposed side of dwelling

Exposure of the Hong Kong Population to Road Traffic Noise

- More than 35% of the population have the most exposed side of their dwelling exposed to L_{DEN} > 65 dB(A)
- Note:

  * Most exposed side

  * External facade



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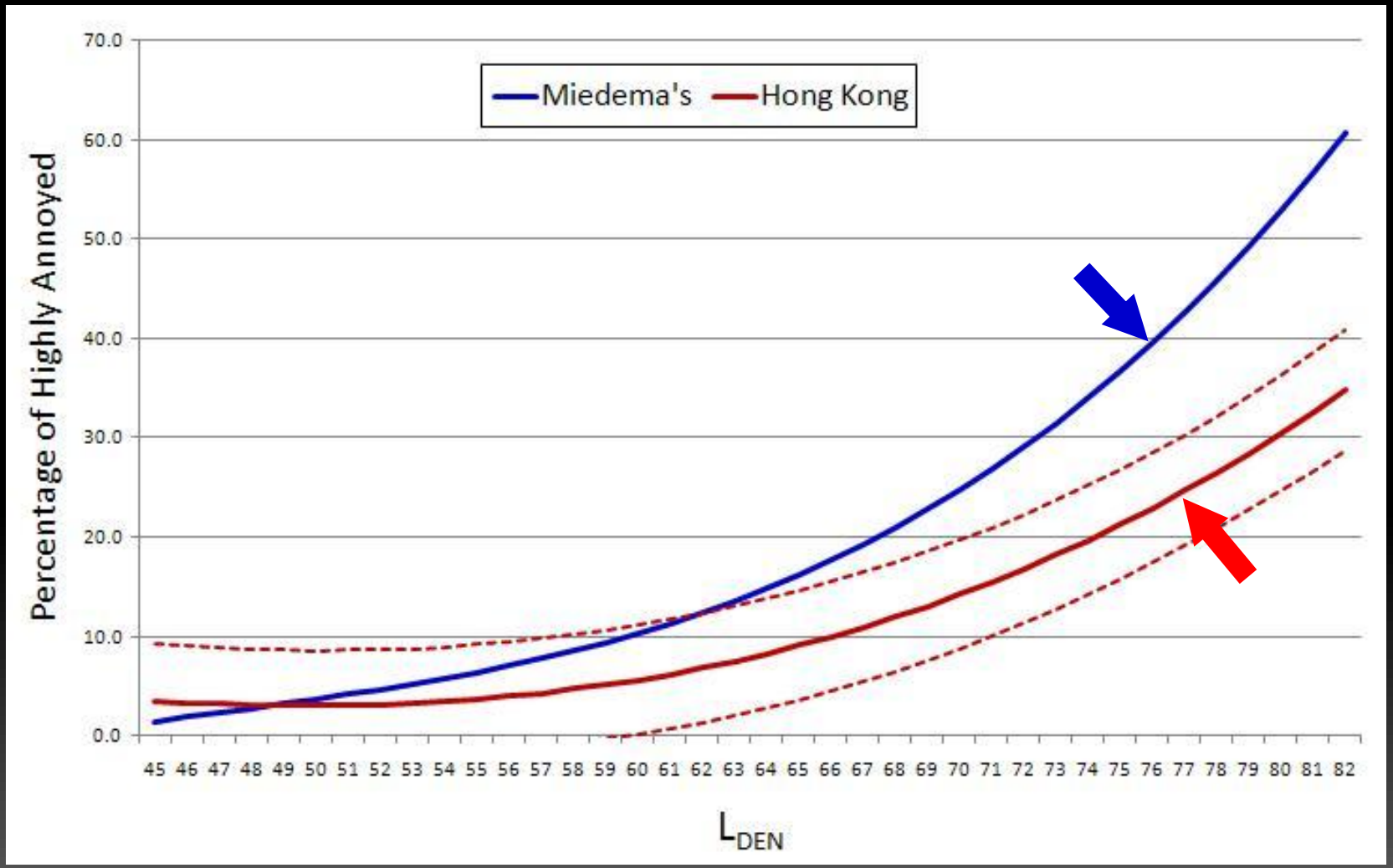
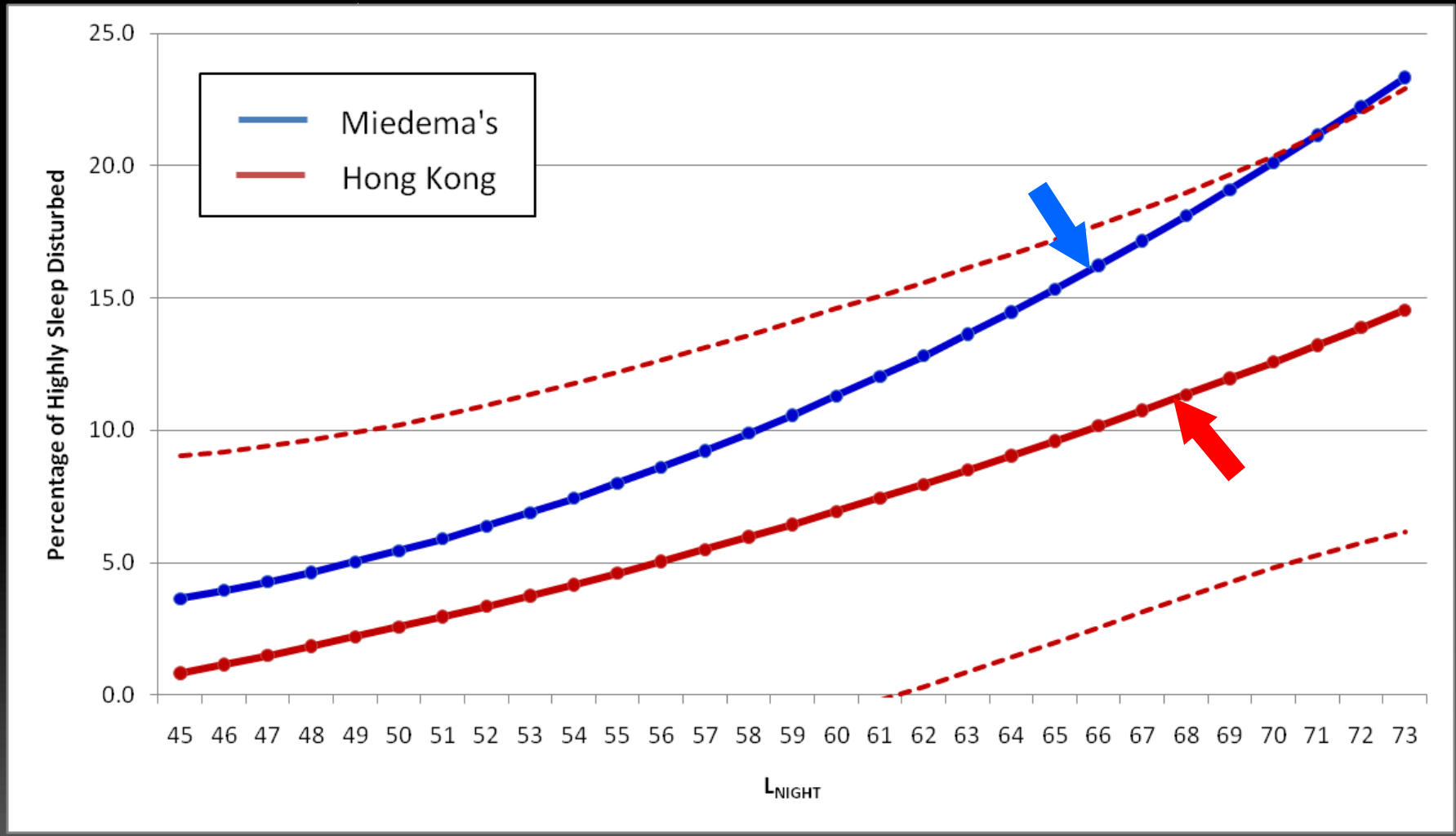
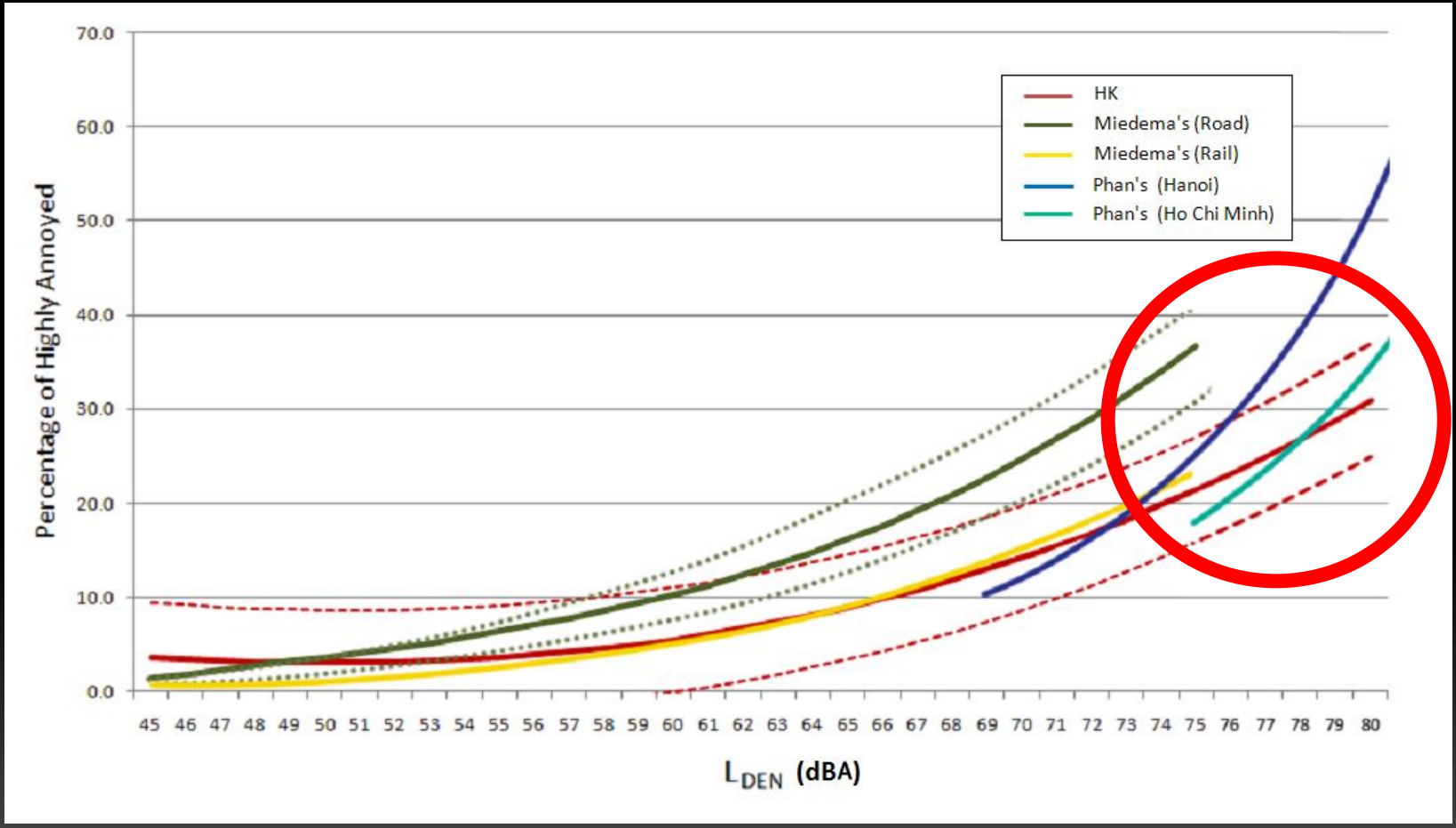
Comparing the HK Exposure - Highly Annoyed Curve with Miedema's



Comparing the HK Exposure - % Highly Sleep Disturbed Curve with Miedema's



Comparison of Hong Kong and Vietnam Curves



Key Questions

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Statistical Analysis

- Binary logistics ordinal regression
  - Binary dependent variable: Highly Annoyed (HA) or not / Highly Sleep Disturbed (HSD) or not?
- With respect to road traffic noise
  - 24h (L_{DEN}) & at night (L_{NIGHT}) respectively
- Key predictor variables
  - Noise exposure - L_{DEN}, L_{night}
- Confounding factors (ordinal)
  - As found in previous studies, results described in next two slides

Factors Affecting whether the Respondent is Highly Annoyed

- Results of binary logistic ordinal regression

Description	Beta coefficient	Level of significance	Odds ratio	Cumulative Nagelkerke R Square	Change in Nagelkerke R Square
Noise exposure					
Noise exposure (L_{DEN})	.74	.000	1.077	.058	/
Physical factors affecting noise exposure					
Access to quiet room	-.758	.000	.469		
Closing window	.257	.000	1.293	.088	.03
Number of household	-.275	.005	.760		
Personal factors affecting perception					
Satisfaction with neighbourhood environment	-.602	.000	.548	.119	.031
Ownership	.218	.008	1.244		
Other personal factors					
Interviewee's noise sensitivity	.453	.000	1.573		
Hearing problems	.481	.012	1.618	.140	.021
Education Level	.132	.032	1.141		

Odds Ratio
> 1
< 1

Factors Affecting whether the Respondent is Highly Sleep Disturbed

- Results of binary logistic ordinal regression

Description	Beta coefficient	Level of significance	Odds ratio	Cumulative Nagelkerke R Square	Change in Nagelkerke R Square
Noise exposure					
Noise exposure (L_{DEN})	.086	.000	1.089	.057	
Physical factors affecting noise exposure					
Access to quiet room	-.821	.000	.440	.083	.026
Number of household	-.350	.014	.704		
Personal factors affecting perception					
Satisfaction with neighbourhood environment	-.460	.000	.631	.099	.016
Other personal factors					
Interviewee's noise sensitivity	.715	.000	2.044	.139	.04
Education level	.201	.012	1.222		

Odds Ratio

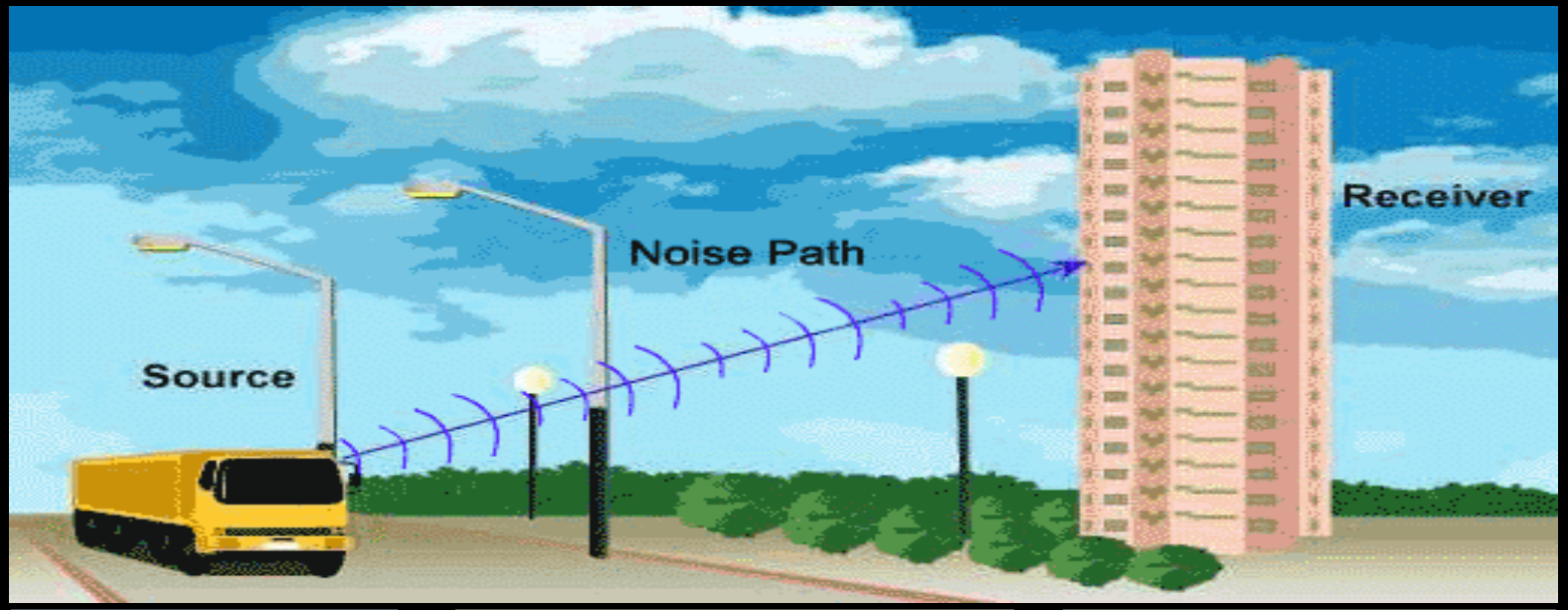
> 1

< 1

Key Questions

- Which noise annoys Hong Kong people most?
- How many people are affected?
- How does Hong Kong people's response compare with that of others?
- Other than noise exposure, what other factors affect annoyance and sleep disturbance?
- What are the implications of the study findings?
  - From source control to innovative building design
  - Recognize limitation of over-reliance on noise reduction
  - Crafting a pleasant holistic sound environment

Ways to Reduce Noise Exposure



Source - traffic volume & composition

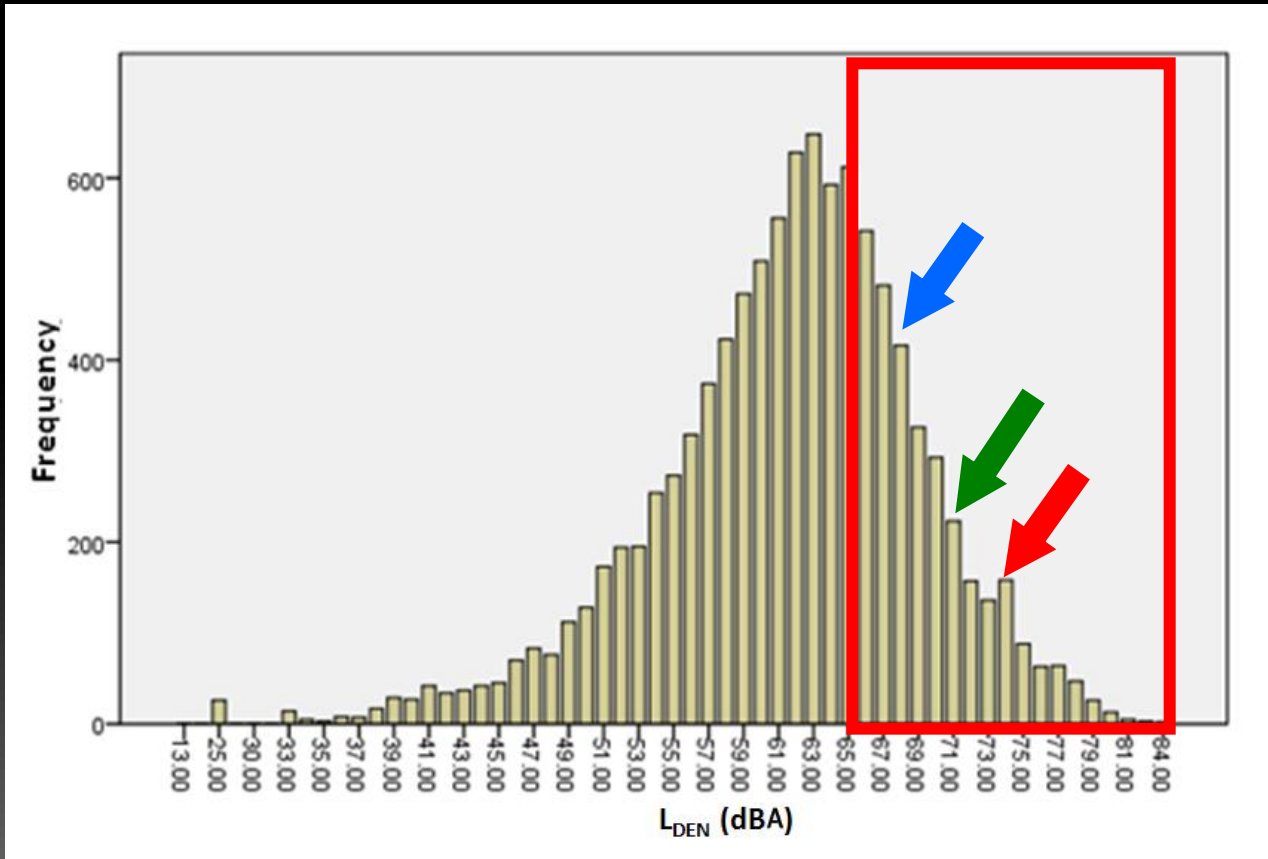
Noise Path – noise barriers

Receiver – building & window design

How Many Cars Have to be Removed?

- Assuming the noise criterion is L_{DEN} 65 dB(A)

To reduce noise by 3 dB, traffic flow has to be cut by half



20th anniversary | Hong Kong Institute of Acoustics

THE JOINT HKIOA-PolyU ONE-DAY SYMPOSIUM

RESEARCH, ASSESSMENT AND DEVELOPMENT OF APPLYING INNOVATIVE BUILDING DESIGNS FOR NOISE MITIGATION– THE LATEST TRENDS

24 May 2013
(Friday)
8:45am - 6:00 pm
Regal Ball
Room B1
Regal Hotel HK
Causeway Bay





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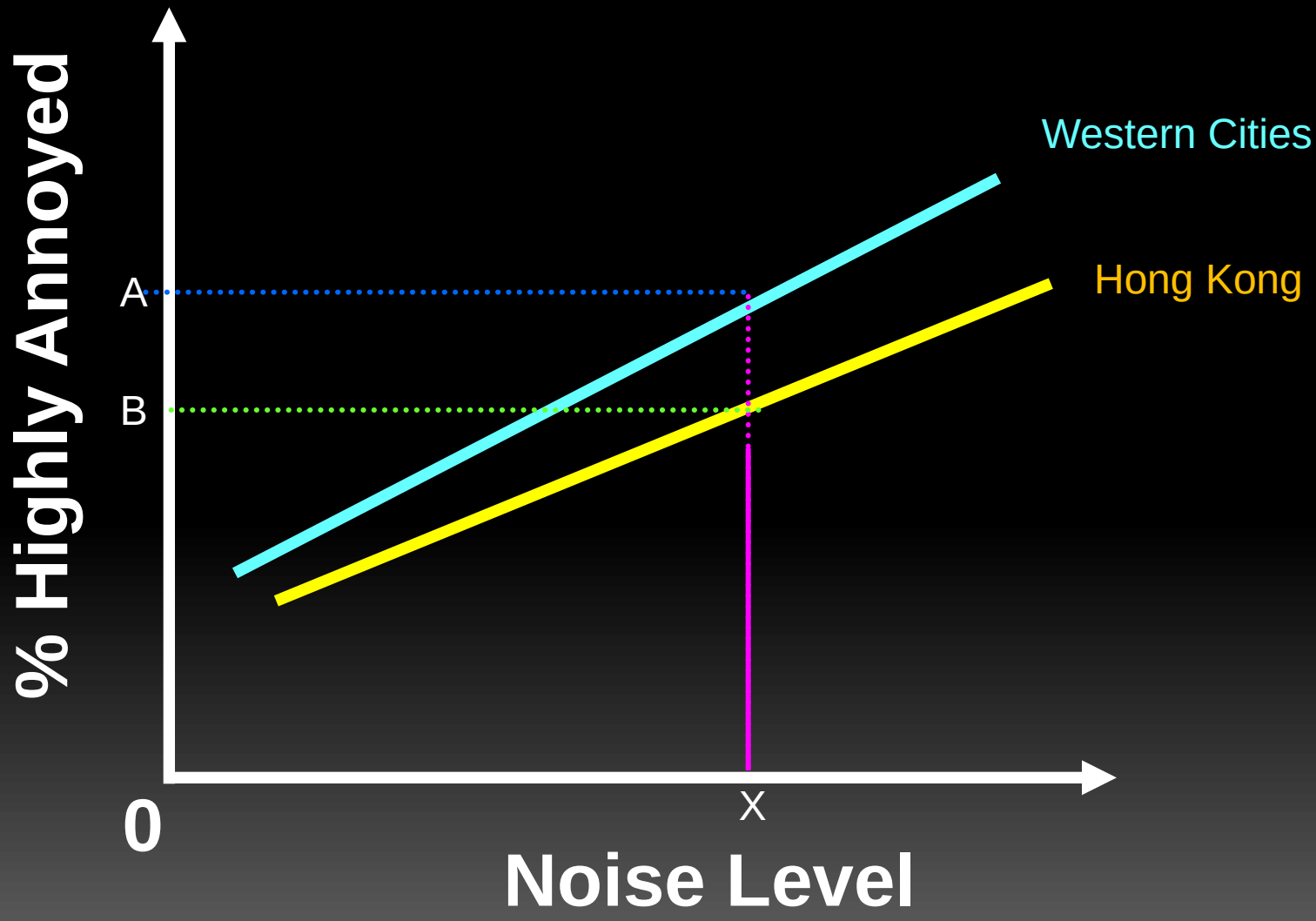
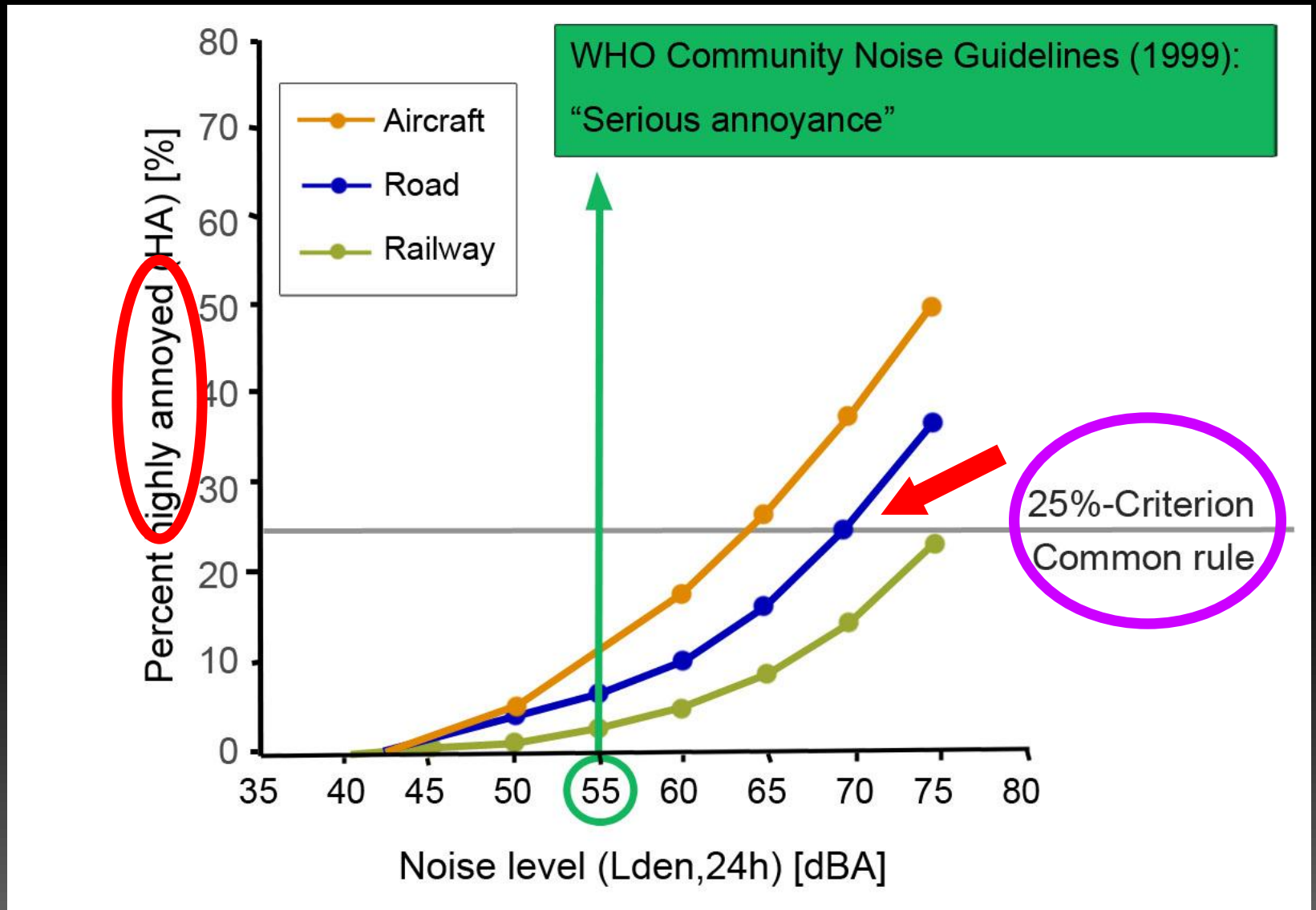
ENVIRON

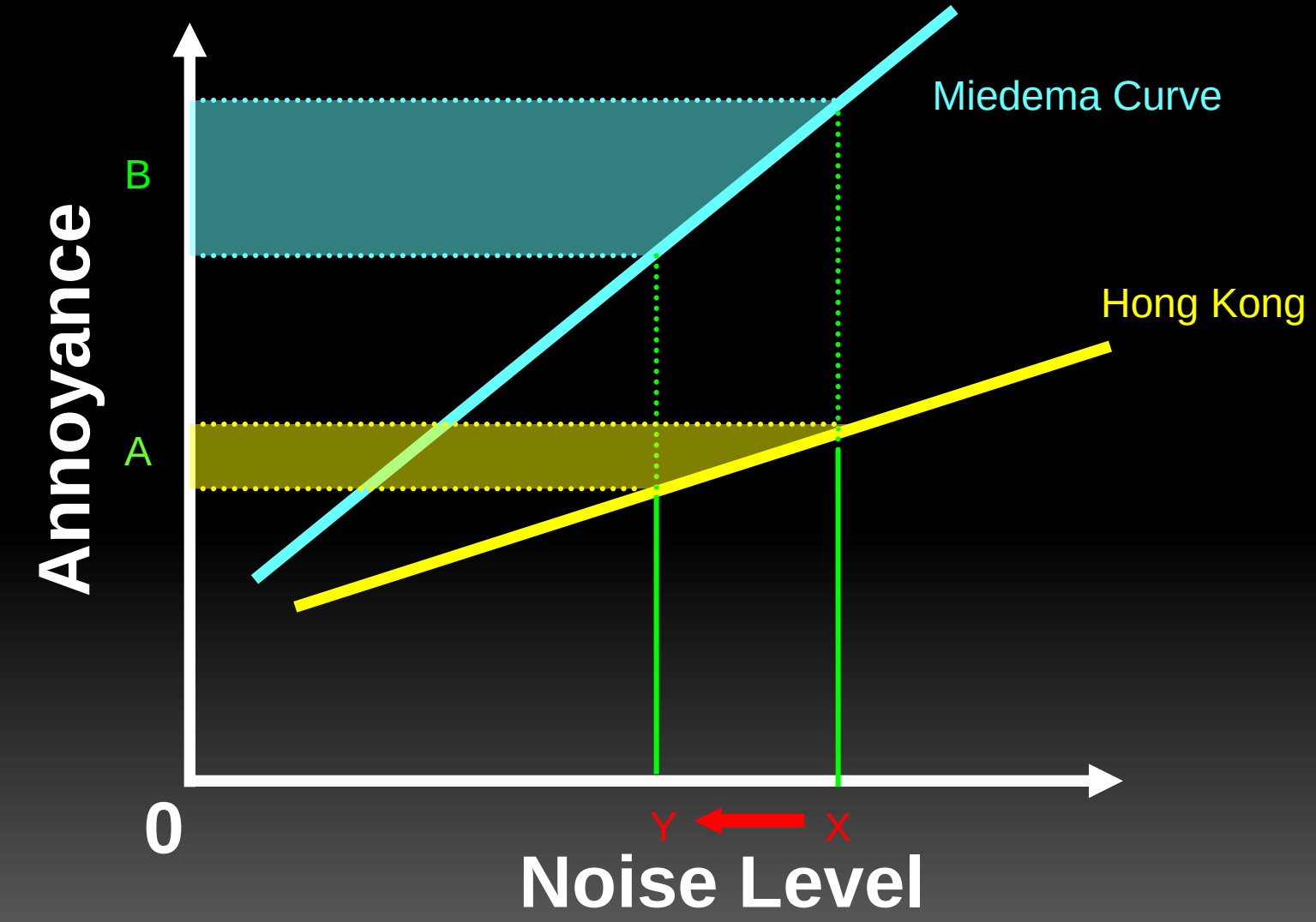
Noise Exposure – Effect Curves



Use of Exposure – Effect Curve for Noise Standard Setting

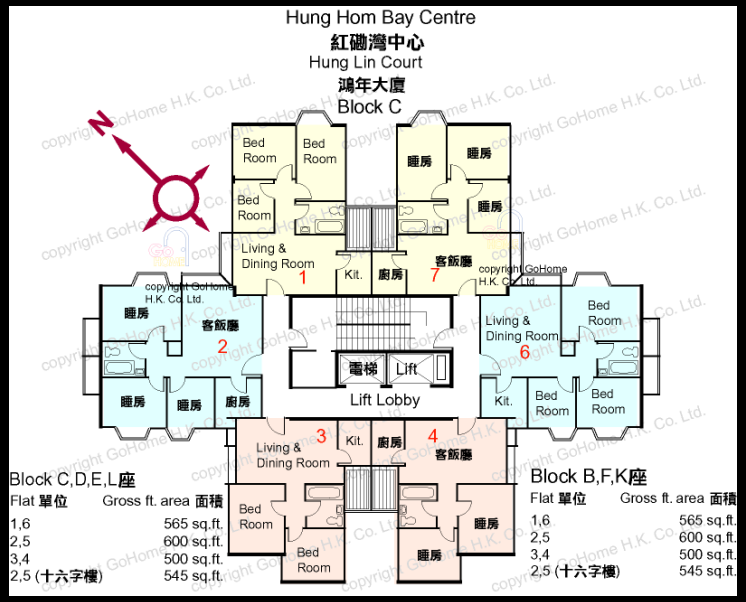


Influence of Slope of Exposure-Effects Curve on Annoyance



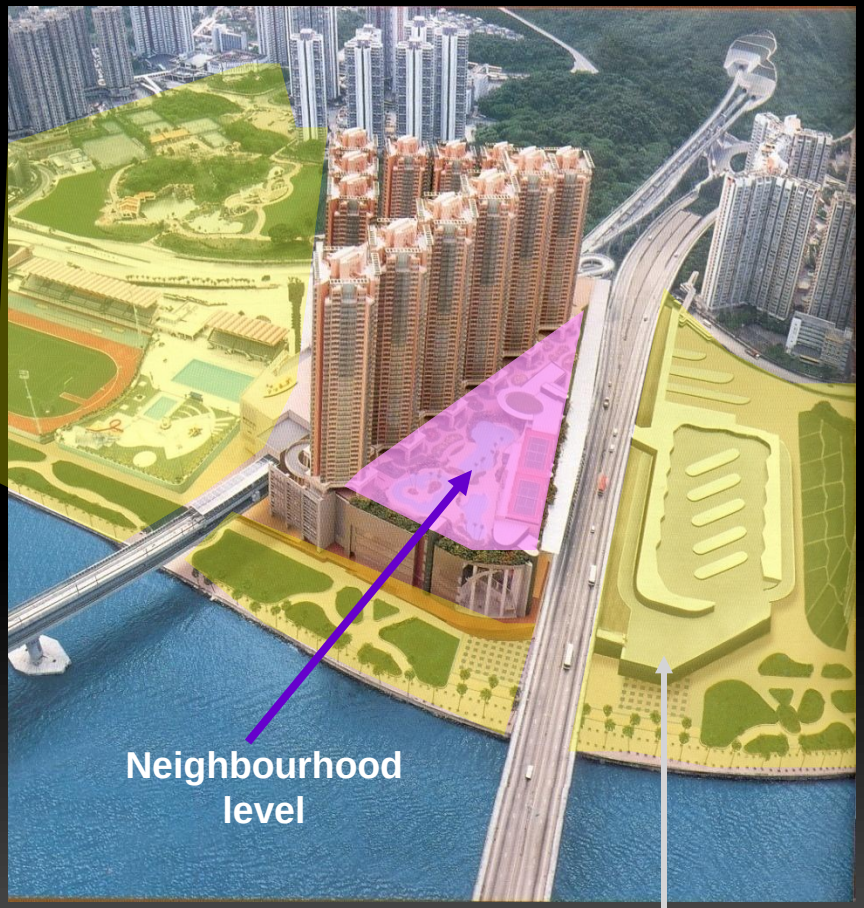
What does this study say?

- Effect of noise exposure is limited
- Intensifying annoyance
  - Ill-heath
  - Noise sensitivity
- Moderating annoyance
  - Good neighborhood environment
  - Access to a “quiet room”



Human annoyance at home and outside their residence and interactions among the effects

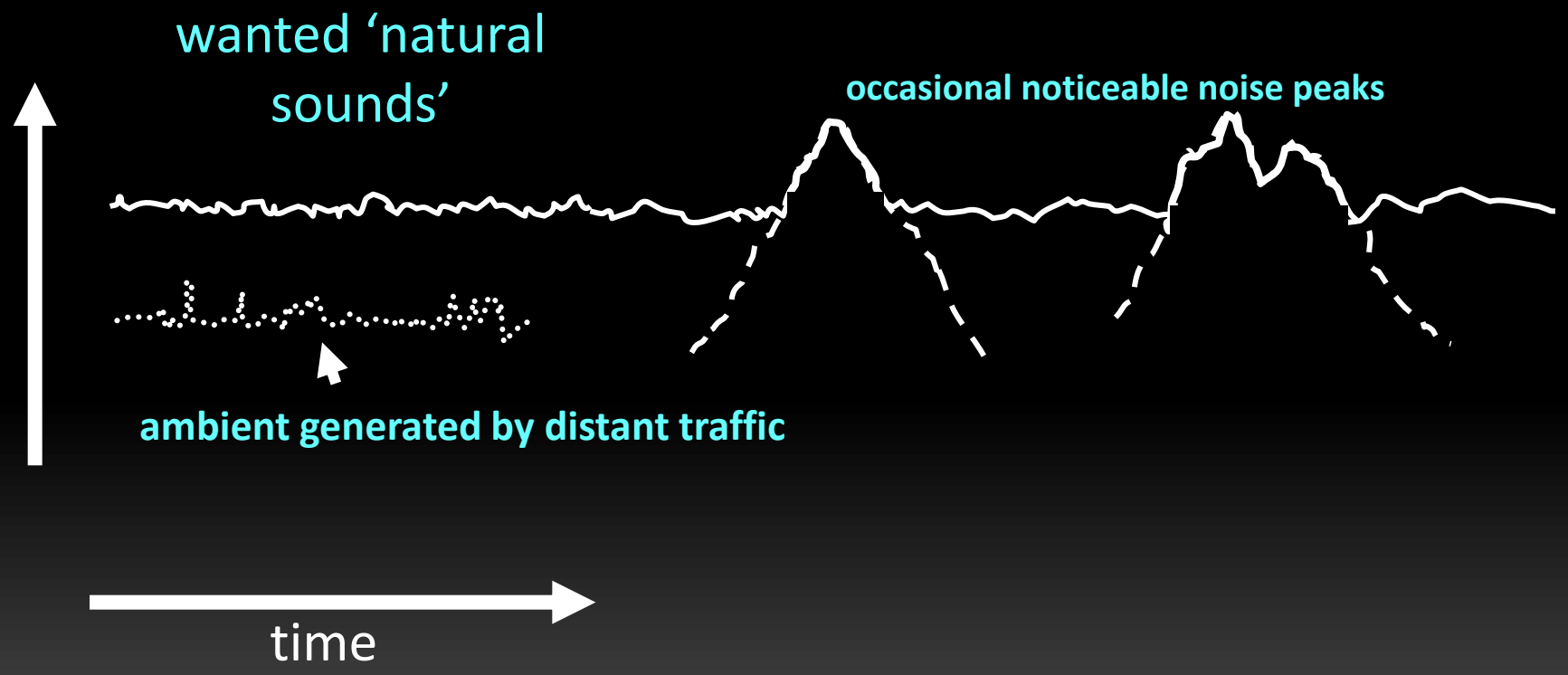
- Dwelling
- Neighbourhood
- Community



Wanted and Unwanted Sound in Cities

- Unwanted - Noise
  - Road traffic
  - Industries
- Wanted
  - Bird songs
  - Water sound

Partial Masking



Source: A.L. Brown

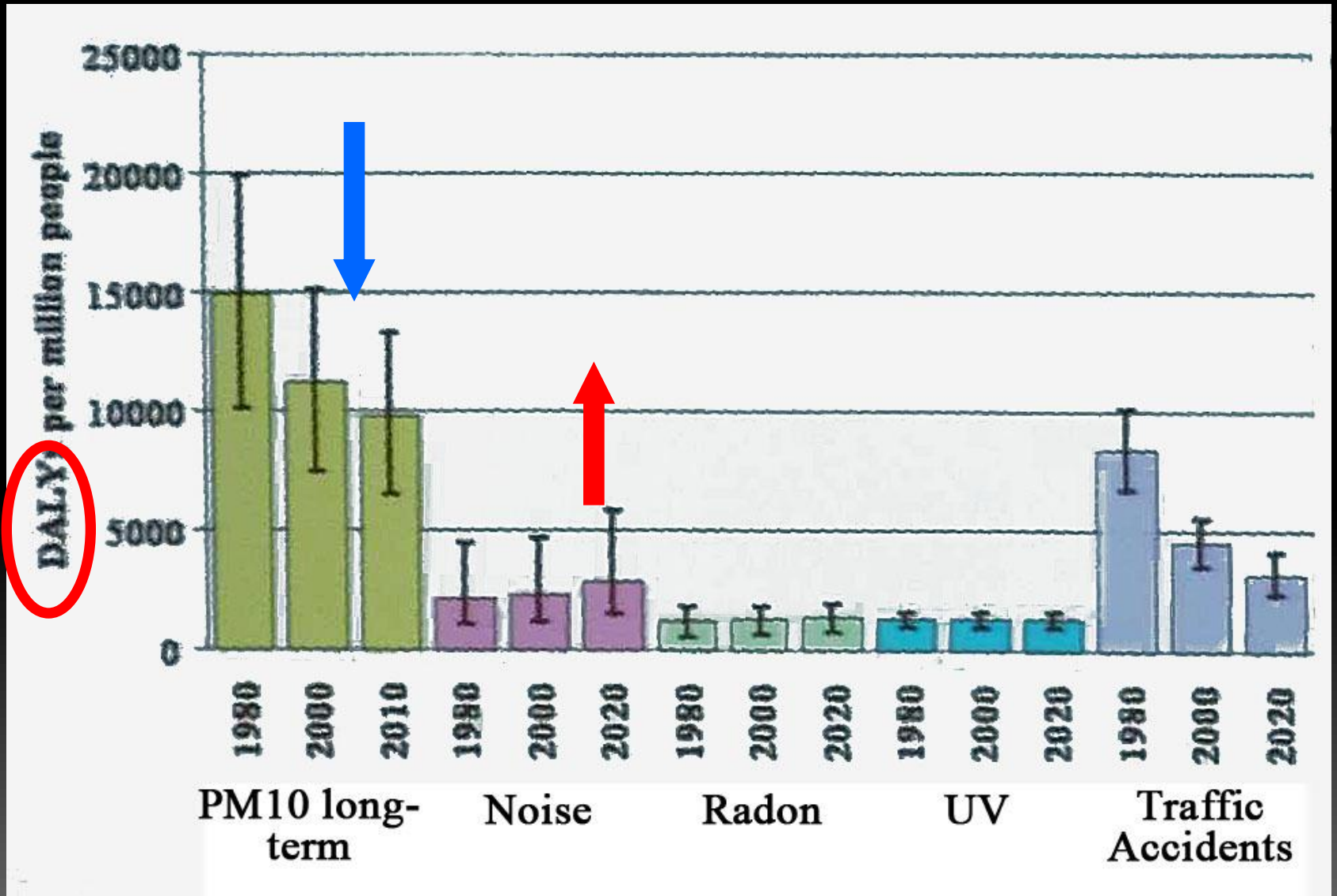
UK's Department for Environment, Food and Rural Affairs

Research into the Practical and Policy Applications of Soundscape Concepts and Techniques in Urban Areas (October 2009)

Approaches to Soundscape Design

- Control negative sound sources
  - Remove, buffer and mitigate
- Preserve and enhance existing positive sound sources
- Add sounds to alter the soundscape or detract attention from existing soundscape features
  - Water sounds, sonic art installation, etc.

Watch Out - Noise-related Health Risks are Increasing (Irene van Kamp, 2010)



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