Do underground workspaces impact workers health?

Summary

As urbanisation continues to rise, two-thirds of the world's population is projected to live in cities by 2050. Singapore, and cities across the world, are seeing subterranean development as a strategy to meet the challenge of accommodating a greater population density. Underground spaces can have a wide range of functions, including public use (e.g., shopping centres), personal use (e.g., garages), transportation (e.g., subways), utilities (e.g., water), and storage (e.g., oil), and can also serve as workspaces (e.g., offices).

In terms of workspaces, underground workspaces pose some potential, but unexplored risks in comparison to aboveground workspaces, such as the limited or lack of exposure to sunlight, sounds from the outside world and potentially worse air quality.[1] The partial or full absence of daylight in underground workspaces which may be additionally dim and inadequately light poses a major concern, as light is the most important biological zeitgeber.[2, 3] Reduced time spent under natural light has been associated with several health outcomes, including sleep disorders, poor mental health, health-related quality of life and vitamin D deficiency.[4-6] However, as yet there is a limited number of studies examining the health effects of working in underground spaces. The majority of these reports have focused on the study of miners and train drivers, while research for other occupations is lacking.[7-12] There is also a lack of studies comparing similar occupations working in above and underground workspaces.

The overarching goal of this thesis is to examine the health effects of underground workspaces compared to aboveground workspaces. For this purpose, this thesis is structured around three main parts, beginning with the initial cohort profile of the workplace study in Singapore to the main findings of the cohort study in Part 2 and 3 of the thesis.

Part 1. Understanding the workplace cohort in Singapore

To study the potential health effects of working in underground workspaces, we developed a cohort study and recruited participants working comparable job types in under and aboveground workspaces. The underground workspaces were not typical basements repurposed for use as a workspace, but instead underground spaces originally designed as workspaces. **Chapter 2** describes the rationale, study design, data collection, and baseline characteristics of the cohort. The study revealed that, at baseline, there were no differences in the health parameters assessed between individuals working in under and aboveground workspaces. The findings also showed that there was a high burden of NCD risk factors among this population. Findings also indicated that there was no difference in the light intensity in

under and aboveground workspaces, and that the light intensity in under and aboveground workspaces was below the levels recommended for indoor workspaces in national and international guidelines.

Part 2. Sleep quality in a working population in Singapore

In the second part of the thesis, we examined different methods to assess aspects of sleep and how it relates to workers' health-related quality of life, and whether working underground is associated with health-related quality of life. **Chapter 3** demonstrates that there is an association between sleep, whether measured subjectively and objectively, and health-related quality of life. This chapter also revealed that there was no difference in health-related quality of life between those working in under and aboveground workspaces.

In **Chapter 4,** we evaluated the underlying factor structure of the Pittsburgh Sleep Quality Index (PSQI) in a working population in Singapore. Findings show that the PSQI encompasses two factors (perceived sleep quality and sleep efficiency) in a working population in Singapore. The analysis illustrated that a two-factor model provides an acceptable fit to the data and was highly superior to the single-factor model. These findings, therefore, suggest that the two-factor model may be more appropriate to use when assessing sleep quality in working populations in Singapore.

Part 3. Health and underground workspaces

In the third part of this thesis, we examined whether working in underground workspaces was associated with psychological distress, 'perceived sleep quality' and 'sleep efficiency'. **Chapter 5** compares the prevalence of psychological distress over time in aboveground and underground workspaces; and additionally assesses the association between perceived indoor environment quality parameters and work-related factors with psychological distress. The study revealed that there was no difference in the prevalence of psychological distress between workers in under and aboveground workspaces. The findings also indicated that dissatisfaction with indoor air quality, temperature, noise and lighting in the workplace was associated with psychological distress, regardless of whether a worker worked in under or aboveground workspaces. Additionally, we observed that working longer hours per day was a risk factor for psychological distress.

Chapter 6 compares the sleep quality of workers, in under and aboveground workspaces, over time using the two-factor model of the PSQI. The study also examines the demographic, lifestyle and workplace factors associated with the two-factor PSQI model, namely 'perceived sleep quality' and 'sleep efficiency'. This study found that working in workspaces that are underground was not associated with worse 'perceived sleep quality' or 'sleep efficiency'. While working underground was not associated with the two sleep quality factors studied, significant associations were observed between a number of workplace factors and 'perceived sleep quality' and 'sleep efficiency'. Longer duration of employment, working in the workshop and greater satisfaction with lighting in the workplace were associated with better 'perceived sleep quality', while greater levels of stress at work and being a shift worker were associated with worse 'perceived sleep quality'.

This thesis sheds light on the health effects of underground workspaces. We studied workers with comparable job types in similar under and aboveground workspaces. The findings of this thesis suggest there are no negative health effects of working in modern underground workspaces when they are comparable to those aboveground. However, the poor sleep health, the high prevalence of psychological distress, and the high burden of NCDs found among workers in this cohort study, suggests workplace policies are needed to improve the health of workers regardless of working in under or aboveground workspaces. Also, irrespective of working in under or aboveground settings, indoor environmental parameters were associated with both psychological distress and worse 'perceived sleep quality', highlighting the key role that this workplace factor has on health, and the need to consider indoor environmental parameters in designing more health-promoting workspaces.

References

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