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Research article

Behavioural changes in air-conditioner use owing to the COVID-19 movement control order in Malaysia

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Abstract

Remote work (working from home) became a norm rather than an exception for the global workforce during the COVID-19 pandemic, influencing every facet of life in both positive and negative ways. The stringent action of the Malaysian government in enacting the Movement Control Order (MCO) motivated the investigation of its impact on the energy consumption behaviour of working people regarding air-conditioner (AC) use. To this end, this study conducted a cross-sectional survey through an online platform. An ordinal logistic regression model (ORL) was used to analyse the collected data of 1873 respondents to determine the factors influencing the ordinal variable of interest, AC-usage behaviour during remote work. Next, the variable with unordered categories, the MCO-induced change in AC-usage behaviour, was analysed using a multinomial regression model (MLT) to identify the potential determinants. Finally, a reason analysis unveiled aspects behind the transition in AC use during remote work. This study identified stopping AC use during remote work despite using it at the office before the MCO period as the most significant change in AC-usage behaviour due to MCO. This change was frequently adopted by people with medium-level incomes and high electricity bills. By contrast, participants unfamiliar with their electricity bill were most likely to start AC use during remote work, although they did not use it before the MCO. Participants working remotely in the communal spaces of their houses preferred to stop using ACs during MCO compared to private room users. Furthermore, age group and ethnicity significantly influenced AC-usage behaviour in remote work and changes in such demeanours. These findings recommend policy interventions to expedite limited AC use for a sustainable energy sector, even during future climatic emergencies.

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1. Introduction

The emergence of the novel coronavirus (SARS-CoV-2) has marked the onset of a new era of uncertainty and immense suffering, leaving the entire world in turmoil. The outbreak of COVID-19 has impacted every corner of the world. The first case presented with pneumonia of unknown cause in Wuhan on 31 December 2019 (Muto et al., 2020). This was soon followed by a surge in infections and increasing death tolls in China and many countries worldwide, leading to a global pandemic (WHO 2020).

To combat the pandemic, countries worldwide imposed restrictions on the movement of their citizens, launching a new lifestyle generally known as “lockdown”. These restrictions have substantially affected almost every sphere of life, including livelihoods, economic activities, health facilities, and social systems (Edomah and Ndule, 2020). Organisations have been compelled to design working and economic activities while conforming to the restrictions. Thus, lockdowns have led to a shift in the perspective of remote working by confining all official, production, and service-related operations as well as educational activities to the home environment. This new lifestyle plays the role of a social science experiment with a remarkable scope for energy scientists. Life under lockdown has entailed a notable shift in energy use habits, which has attracted the attention of researchers worldwide. Disruption of the well-established daily routine while adapting to the newly restricted life could redistribute the peak demand period and moderate the peak-hour consumption, offering more flexibility in using home appliances (Grünewald, 2021; Grünewald, 15 September 2021).

A study on New York City’s energy consumption reported a significant increase in domestic energy consumption. An increase
in individual energy demand during the usual working hours on weekdays has also been reported here. This study discussed the possibility of additional cooling load during the summer days, which may worsen the economic burden on people due to increasing electricity bills (Meirenken et al., 2020). European countries with stringent preventive measures, such as Spain, Italy, Belgium, and the UK, recorded an electricity consumption profile that was observed during the weekends in 2019 preceding the pandemic period (Bahmanyar et al., 2020). Consumers in the UK adopted a smoother usage pattern during morning peak hours by postponing their early-morning activities to later (Menneer et al., 2021). By contrast, with no lockdown during the pandemic period, Sweden illustrated an increase in electricity consumption compared to the pre-pandemic days (Bahmanyar et al., 2020). After the enactment of social distancing in Brazil, the overall electricity loads fell, and the highest reduction was observed in the South subsystem (de Delgado et al., 2021). Despite the pandemic-induced drop in total electricity consumption, the lockdown substantially exacerbated the prevailing energy poverty worldwide by increasing domestic energy demand amidst the financial crisis (Mastropietro et al., 2020).

Overall, the energy consumption behaviour of people worldwide is being restructured throughout the pandemic and accompanying restrictions. This situation necessitates a subtle analysis of this issue, especially when climate change has already made it essential to attain sustainability in energy, social ecology, and economy (Wheeler, 2011). Many studies have reported a positive association between climate change and energy consumption. In Shanghai, China, changes in daily temperature significantly increased electricity consumption, and this association was found to be more prominent during warm days than during cold days (Li et al., 2019). Climate change is projected to increase the additional peak load in the USA during the summer (Bartos et al., 2016). The trend of energy demand for heating and cooling has increased since 1990 due to climate change. It is projected to increase continuously until 2030 (Deroubaix et al., 2021). The change in the climate of Melbourne, Australia, which generally has a temperate and oceanic climate, was estimated to lead to an increase in peak demand for electricity from 2000 to 2100. This study considered the ownership of air conditioners (ACs) during the early phase of the 21st century (Lipson et al., 2019). Most of these studies observed a more pronounced climate-energy association for the warm period, and ACs were identified as the main factor catalysing this relationship. Therefore, the change in energy consumption behaviour due to the newly restricted lifestyle can be prominent on hotter days.

Malaysia is characterised by hot and humid weather throughout the year; thus, AC is a commonly used cooling appliance. To ensure the thermal comfort of the occupants, 53% of the electricity consumption in Malaysian buildings, from both commercial and residential sectors, can be attributed to ACs (Shaikh et al., 2017). According to the Laos Census 2015, 41.6% of the households in Malaysia contain ACs, while the capital of Malaysia, Kuala Lumpur, reports 45.6% individual AC ownership (Consumer Appliances in Malaysia 2015). The AC-usage pattern of Malaysian people during the pandemic can play a salient role in attaining energy sustainability, as they had to maintain a different lifestyle, embracing strict restrictions. The Malaysian government implemented the “Movement Control Order” (MCO) on 16 March 2020 to prohibit mass movements and all types of gatherings to curb the spread of coronavirus. With the MCO, all business organisations were restricted, except those engaged in manufacturing and supplying food, personal care, and pharmaceutical products (Tang, 2020). The control order was extended to 3 May 2020 after which various reforms were initiated, curtailing the degree of restriction (Fan and Cheong, 2021). The Energy and Natural Resources Minister of Malaysia reported that the MCO promoted domestic electricity use by 23%, although the overall electricity use decreased by 33% during this period (BERNAMA 2021). To withstand the MCO-time economic burden, the national energy provider of Malaysia, Tenaga Nasional Berhad (TNB), announced tieredrebates on electricity bills through the Bantuan Prihatin Elektrik (BPE) package (BERNAMA 2020). The government of Malaysia also implemented several economic stimulus packages, along with discounts on electricity bills, for the residents of Peninsular Malaysia.

Thus, the behaviour of Malaysian consumers regarding a typical cooling appliance (AC) during the MCO period, in response to the abovementioned packages, could be highly informative in the field of building environmental engineering. Furthermore, any significant change in AC-usage behaviour owing to MCO implementation may highlight the AC-use behaviour with a focus on achieving energy sustainability. To this end, this study conducted a questionnaire survey to investigate the behavioural changes in work-time AC use between office work (pre-MCO) and remote work (during MCO). The collected data were analysed to detect the potential factors related to these changes. Through this analysis, we examined how this new evolving practice can be targeted to establish a more sustainable and energy-efficient lifestyle.

2. Literature review

The concept of remote work or telework is not merely an innovation of the pandemic, as this work arrangement has already been established and gradually embraced over the past several years. However, the outbreak has helped facilitate its acceptance amongst workers (ILO, 2020), amongst the European Union countries, the pre-pandemic teleworking modalities were mostly occupied by knowledge-intensive services, educational activities, finance-related work, information communication technology professionals, high-paid employees, and business managers (European Commission, 2020). The teleworking space has been expanded to low-and mid-level clerical employees to comply with COVID-19 restrictions (Sostero et al., 2020). Thus, the pandemic has changed global work cultures, particularly in countries with high transmission rates. A new era of teleworking with all its benefits and pitfalls has emerged through the outbreak. It may be sustained even after the pandemic days (Guyot and Sawhill, 2021). Therefore, it is important to work on the challenges associated with the teleworking space to achieve the highest productivity and ensure work-life balance.

In Malaysia, 67% of the active companies adopted remote work. Amongst the working people, multinational corporate officials, staff with salaries more than MYR 6000 (USD 1442.13), and the inhabitants of Kuala Lumpur were more likely to embrace teleworking during the COVID-19 pandemic (Laws of Attraction 2021). However, this trend has already started to gain popularity during the pre-pandemic period (Teh et al., 2013). Most Malaysian people are still struggling to adapt to this new working environment. At the same time, companies are worried about the effects of telework adoption on productivity. A comfortable virtual working environment can ensure higher productivity and the welfare of companies (BGC, 2021). Vischer (2004) emphasised the impact of physiological comfort on worker performance. Ambient environmental conditions, such as lighting, acoustics, ventilation, and thermal comfort, were highlighted in this case. Poor indoor environment quality (in terms of lighting, air quality, and noise insulation) was also found to deteriorate the adequacy of the teleworking space (Cuerdo-Vilches et al., 2021). For Malaysia, indoor thermal comfort has been an imperative research topic because of its geographical location. The year-long exposure of buildings to high temperatures (with average daily temperature ranging from 21 °C to 32 °C) and humidity—as well as high-intensity solar radiation—is the usual climatic condition of Malaysia (Shaikh et al., 2017; Gou et al., 2018).
The continuous increase in AC installations and energy consumption (Shaikh et al., 2017; Gou et al., 2018; Koh et al., 2018) has motivated researchers to seek a reasonable balance between indoor thermal comfort and environmental impact.

The abundant use of AC has led to several studies encouraging energy conservation behaviour to develop sustainable energy for future generations. Ting et al. (2011) demonstrated the urgent need to save energy as a preventive measure against energy sustainability threats in Malaysia and other countries throughout the world. Jalalkamali and Abbas (2014) suggested a significant reduction in energy use by raising awareness amongst occupants regarding energy sustainability. Some psychological aspects, such as attitudes, norms, behaviour control, habits, motivation, and knowledge about energy, were successfully identified as determinants of occupants’ energy-saving behaviour (Mansor and Sheau-Tangi, 2019). Therefore, it would be interesting to determine whether the energy consumption pattern of people with the wider application of remote work can encourage them to adopt an energy-efficient lifestyle.

Several studies have already projected energy transitions due to the enforcement of movement restrictions in various countries worldwide during the pandemic. For example, Qarnain et al. (2020) determined that social distancing and home quarantine were two of the most influential factors for intensive energy conservation behaviour during the pandemic in India. Jiang et al. (2021) explored the impact of the pandemic on energy consumption and demand, highlighting the environmental impacts and lessons regarding energy recovery. In China, the impact of lockdown on domestic energy consumption was determined along with predicting the post-lockdown consumption pattern (Cheshmehzangi, 2020). A substantial increase in energy consumption due to household cooking, entertainment, heating and cooling, and lighting was identified. However, only the cooking-related consumption pattern was predicted to shift during the post-lockdown period. A study focusing on the Lagos metropolis of Nigeria compared the overall electricity demand of various sectors, such as residential, commercial, and industrial, before and during the partial lockdown (Edomah and Ndulue, 2020). No significant change in the share of overall electricity demand amongst these sectors was observed in this study. However, the enforcement of total lockdown depicted a different scenario, with a sharp increase in residential electricity demand and a declining demand within the industrial sector. Most of these studies focused on the overall energy consumption or electricity use in a building, rather than on any specific equipment. To project the perceived change in a definite way, the current study analysed the impact of the MCO on energy consumption behaviour through the most common cooling appliance in Malaysia (AC).

3. Methods
3.1. Study area

This study attempted to determine the behavioural changes in AC use due to COVID-19 MCO enforcement in Malaysia. Although regional variation is evident in the climate, this country has no significant seasonal changes over the year. Being located near the equator, Malaysia has an equatorial climate, hot and humid, with a year-long summer (except in high-altitude areas) and rain. However, high temperatures persist throughout Malaysia. The average temperature of plain areas ranges between 25 and 32 °C, with 75% humidity throughout the year, and it is sufficient to make one wet without rain. The daily average temperature and relative humidity (RH) of Malaysia from July 2019 to June 2020 are shown in Fig. 1.

Fig. 1 depicts no substantial difference in the daily average temperature before and during the MCO implementation. Even after 3 May 2020 when a few MCO restrictions were relaxed and the MCO measure was transformed into a conditional movement control order (CMCO), the average temperature did not vary significantly. Most of the days were recorded during these periods, with an average temperature ranging between 26 and 31 °C. In the case of RH, although the MCO days were more humid than the pre-MCO period, the average RH exceeded 70% for most of the days before MCO enforcement. This implies that the pre-MCO days were not comfortable in temperature and humidity, as in the MCO period. Thus, it can be assumed that the influence of meteorological factors on MCO-day AC use behaviour is identical to that of other periods of the year.

Vernacular Malay houses of the traditional style normally use lightweight materials and rely on natural ventilation to deal with hot and humid weather characteristics (Kubota et al., 2021). However, in recent years, such houses have rarely been found in urban areas. According to the national census of Malaysia, approximately 85% of urban houses are made of bricks or brick slabs (General Report of the Population and Housing Census 2000). These modern houses necessitate AC use to withstand tropical climatic conditions, which has contributed to a salient increase in AC use.
ownership (from 0.8% in 1970 to 41.6% in 2015) amongst Malaysian people (Consumer Appliances in Malaysia 2015; General Report of the Population and Housing Census 2000). According to the average floor area of dwellings, Malaysia has secured the ninth position (approximately 117.43 m²) in a list of the top 52 countries. However, in Malaysia, the floor area per person is 27.30 m², which degrades Malaysia to fall behind some developed Asian countries such as Japan and Taiwan, well-known countries for small dwellings (Foo, 2019).

3.2. Survey and questionnaire

A cross-sectional survey, spanning from 12 May to 19 May 2020, was conducted using an online platform by a Malaysian online research company. Although the survey period coincided with the hottest month (May) in Malaysia, it enquired about AC-usage behaviour during the MCO period. Thus, it concentrated on hot summer days, which are common in the usual climate of Malaysia. The data were collected by targeting people who visited the associated online publisher websites (OPWs), such as online news portals, sports, and lifestyle websites. People browsing these high traffic websites during the survey period noticed a single question from the questionnaire of the survey in the form of pop-up advertisements. On the visitors’ subsequent visits to various high-traffic websites, they were shown the consecutive single question of the survey. Repeated and regular visits to consume content over various OPWs made it possible for visitors who passed the screening process to complete the questionnaire. As this study was purported to unveil new AC-usage behaviour in remote work, the screening question enquired whether the respondents worked remotely during the MCO period. Only the visitors of the associated OPWs who adopted MCO-days remote work were eligible to participate in the survey. It was a completely anonymous survey where eligible visitors participated based on their willingness and were free to answer or skip any survey questions. All procedures performed in this work regarding data collection and analyses were in accordance with the ethical standards of Kyushu University.

The questionnaire (attached as supplementary information in the S1 file) of the survey comprised 12 questions. It enquired about demographic characteristics, such as age, gender, and ethnicity, followed by some social status-related questions, such as monthly household income and residential house type. Each question provided a specified number of options from which the respondents had to choose their answers. However, the second part of the questionnaire concentrated on the most important enquiry, which was how frequently a respondent used ACs while working remotely during the MCO period. One possible answer to this question was “AC is not installed in-house”. The respondents who chose this option (10.99% of the respondents) were excluded from the analyses. Additional questions regarding remote working rooms, reasons for both using and not using an AC during the MCO period, monthly household electricity bill, and previous AC-usage behaviour at the office were also incorporated into the questionnaire.

3.2. Data and variables

This study analysed data extracted from 5076 participants who answered the most important question for this work: how frequently they used ACs while working remotely during the MCO period. The analysis procedure was divided into three sections: AC-usage behaviour during remote work, changes in AC-usage behaviour due to MCO, and reasons for such changes.

The first section analysed AC-usage behaviour during the MCO period, extracting information on the frequency of AC use while working remotely. This variable was the response variable of this section and named as “AC-usage behaviour during MCO”. It was a categorical variable with four categories (not used, rarely used, sometimes used, and always used). The explanatory variables for this section were divided into four groups: previous behaviour, dwelling conditions, economic conditions, and demographic characteristics.

In the second set of analyses, changes in AC-usage behaviour due to MCO implementation were analysed. This section used a new response variable that combined AC-usage behaviour during the MCO period and AC usage at the office before the MCO period. New AC-usage behaviour during the MCO period was recategorized by combining the categories “not used” and “rarely used” into a new category “not used”. Another new category, “used”, accumulated the old categories “sometimes used” and “always used”. This recategorized AC-usage behaviour during the MCO period and AC usage at the office before the MCO period were combined, resulting in two possible behavioural changes. Those who used ACs at the office before the MCO period but did not use ACs during the MCO period were classified as “stopped AC use during MCO”. The behaviour of not using ACs at the office before the MCO period but using during the MCO period indicated the second type of change, that is, “started AC use during MCO”. The remaining two combinations revealed no change in AC-usage behaviour. They were merged to form the “no change” category. Thus, the variable change in AC use, with three categories (no change, stopped AC use during MCO, and started AC use during MCO), was constructed to project behavioural changes in AC use.

Amongst the set of covariates, monthly household income, monthly household electricity bill, and age group were categorized based on numerical values. The respondents with monthly household income below MYR 5000 (USD 1195.74) and between MYR 5000–10,000 (USD 1195.74–2391.49) were categorised into low- and medium-income groups, respectively. The category of high income consisted of participants whose monthly household income exceeded MYR 10,000 (USD 2391.49). This categorisation was based mainly on income classification by households in Malaysia. Some respondents preferred not to reveal their income levels. These respondents constituted the “not exposed” category of this covariate. In the case of monthly household electricity bills, the categories along with the numerical range of values are low (< MYR 101 or USD 24.14), medium (MYR 101 to MYR 400 or USD 24.12 – USD 96.17), high (MYR 401 and above or > USD 96.41), and unknown. The unknown group encompassed respondents unfamiliar with their monthly household electricity bills. People aged between 18 and 30 years comprised the young age group, while the middle-aged category included participants aged > 30 years and not more than 50 years. Respondents aged more than 50 years were assigned to the “older” group.

To provide a summary of all the variables analysed in this study, the descriptive statistics of the respective categories of each variable, as well as the 95% confidence intervals of their percentages, are presented in Table 1.

According to Table 1, about half of the respondents (54.20%) in this study did not use ACs during remote working in the MCO period. During that period, 17.30%, 12.47%, and 16.04% of the respondents used ACs rarely, sometimes, and always, respectively. The differences in the percentages between all possible pairs of these categories, except for the rarely used and always used categories, are statistically significant, owing to the non-overlapping confidence intervals. The change-related response variable encompassed information from a total of 2772 respondents, while the number of respondents who answered the question regarding AC-usage behaviour during remote work was 5076. This is because the change variable combined data regarding AC-usage behaviour during the MCO period and AC usage at the office before the MCO period, and only 2772 participants responded to the latter question. Thus, combining these two variables resulted in the new out-
come variable, change in AC use, consisting of 2772 responses and depicted no change in the behaviour of more than half of them (58.04%). The start of AC use during the MCO appeared to be an unimportant behavioural change, comprising only 6.35% of the respondents, whereas 35.61% of the respondents stopped AC use. The joint confidence intervals of this variable indicate a significant difference in the percentages of these categories, amongst the covariates, the percentages of respondents for the categories of AC-use behaviour at the office before the MCO period (44.73% and 55.27%) were numerically similar. The type of working room at home also resulted in similar percentages (53.95% and 46.05%). Most of the respondents (77.90%) dwelt in buildings other than high rise, amongst the survey participants, 45.90% belonged to the low-income group, defined as the bottom 40% of earners in Malaysia (B40). Only 20.84% of the respondents were categorised into the medium-income group, constituting the middle 40% (M40) Malaysian people. By contrast, the high-income group representing the group with top 20% income of the Malaysian population, comprised 13.77% of the respondents. The percentage of participants who did not expose their monthly household income was 19.48. More than half (62.86%) of the respondents' monthly household electricity bills were at the medium level, and low electricity bills were observed amongst 26.66% of the participants. Both middle-aged (67.71%) and male (63.67%) respondents were dominant amongst the survey participants. Malay people comprised 85.09% of the respondents, a much higher percentage than the respondents from any other ethnic group.

3.3. Methodologies adopted for statistical analyses

The statistical analyses for all three sections of this study were conducted using three major processes. The analyses started by extracting the descriptive statistics of the selected variables, followed by bivariate analyses. The first two sections (AC-use behaviour during remote work and changes in AC use due to MCO) used bivariate analyses to identify the factors significantly associated with the outcomes of interest. The bivariate analyses relied on bar charts to illustrate unadjusted associations between the dependent variable and selected covariates and the chi-square test of independence to check the statistical significance of these associations. Since the unadjusted association between two variables (one covariate and the dependent variable in the present study) was investigated by bivariate analyses, further analysis was required to justify the associations found to be statistically significant in the bivariate analysis. Therefore, all the significant covariates of the bivariate analyses were incorporated into regression models to examine the fitted associations between the responses and the corresponding potential factors.

The AC-use behaviour during remote work was analysed using an ordinal logistic regression model (ORL) (McCullagh, 1980; Ananth and Kleinbaum, 1997; Lall et al., 2002; Abreu et al., 2008; Mohammad et al., 2017). The multinomial regression model (MLT) investigated the changes in AC-use behaviour at work owing to MCO implementation (Bayaga, 2001). The last section of the study explored the various reasons behind the transition in AC-use behaviour from the pre-MCO period.

### 3.3.1. Ordinal logistic regression model

An ORL relies on the cumulative logit link function, which preserves order in the outcome variable. The regression coefficients of the covariates can be easily converted into odds ratios (ORs), as these coefficients are independent of category (Agresti, 1996). This provides a convenient method for understanding and interpreting the effects.
Suppose that an ordered categorical variable involves \( j (> 2) \) categories, and the response obtained from the \( j \)th \((i = 1, 2, \ldots, n)\) individual is denoted by \( Y_i \). Let \( X_i = (x_{i1}, x_{i2}, \ldots, x_{ik}, \ldots, x_{in})' \) be the \((K \times 1)\) vector of covariates for the corresponding individual, and \( \beta = (\beta_1, \beta_2, \ldots, \beta_k, \ldots, \beta_K)' \) be the \((K \times 1)\) vector of the regression coefficients. Furthermore, let the odds for the \( j \)th category of the \( i \)th individual be defined as:

\[
\theta_{ij} = \frac{\Pr(Y_i \geq j)}{\Pr(Y_i < j)}
\]

Thus, the ORL can be written as follows (Mohammad et al., 2017):

\[
g_{ij} = \ln \left( \theta_{ij} \right) = \alpha_i + \beta' x_i;
\]

where \( \alpha_i \) is the threshold term for the \( j \)th category, and the OR of the covariate \( x_i \) can be computed by taking the exponent of the corresponding coefficient estimates, \( \exp(\beta_j) \).

3.3.2. Multinomial logistic regression model

The basic concept of the MLT is that it is a generalised version of the binary logistic regression model (El-Habil, 2012), which uses a logit link function to analyse a binary dependant variable. In MLT, the multivariate (more than two) nominal outcomes are analysed, conducting binary logistic regression models for each category of the response variable involving an arbitrary reference category (Aziz et al., 2016).

Suppose that a response variable \( V \) has \( Q (> 2) \) nominal (unordered) categories. For such a response variable, the MLT consists of \((Q - 1)\) non-overlapping logit models. Let the \( Q \)th category of the response be the reference category and \( u_p = (u_{p1}, u_{p2}, \ldots, u_{pm}, \ldots, u_{pq})' \) be the \((L \times 1)\) vector of the covariates from the \( p \)th \((p = 1, 2, \ldots, q)\) individual. The \( Q \)th logit model can then be written as follows (Aziz et al., 2016):

\[
\eta_{pq} = \ln \left( \Pr(V_p = q | u_p) / \Pr(V_p = Q | u_p) \right) = \nu_q + \gamma_q' u_p;
\]

where \( \nu_q \) is a constant and \( \gamma_q = (\gamma_{q1}, \gamma_{q2}, \ldots, \gamma_{qm}, \ldots, \gamma_{qQ})' \) is the \((Q \times 1)\) vector of the regression coefficients associated with the \( q \)th category of the response. The estimated regression coefficient of the model can be interpreted easily using relative risk ratio (RRR). The RRR for the covariate \( u_i \) can be estimated using the following formula:

\[
\text{RRR}_{Q_i} = \exp \left( \frac{\nu_q}{\gamma_q} \right)
\]

where \( \text{RRR} \) denotes the RRR estimate and \( \gamma_q \) is the estimated regression coefficient.

R software was used to analyse data using these models. The parameters of the ORL were estimated using the “polr” function of the R (version 4.1.1) package “MASS” while the “multinom” function from the “nnet” package was used for the MLT.

4. Result and discussion

4.1. AC-Usage Behaviour during remote work

The response variable for this section was AC-usage behaviour during the MCO period, consisting of four categories: not used, rarely used, sometimes used, and always used. Four types of covariates (previous behaviour, dwelling conditions, economic conditions, and demographic characteristics) were selected to detect the potential factors of AC-usage behaviour in remote work. Fig. 2 displays the results of the bivariate analysis of AC-usage behaviour during remote work.

The figure presents the percentages of the response variable AC-usage behaviour categories during the MCO period for varying levels of each covariate. The error bars (representing 1.96 standard errors) are attached to this figure to pinpoint the categories that showed substantial differences. The chi-square test of independence was used to identify the covariates associated significantly with the response variable. The corresponding \( p \) values were incorporated into Fig. 2. The \( p \) values of the figure indicate the significant unadjusted association of all covariates with the outcome of interest. Moreover, the behaviour of not using ACs during the MCO period appears to dominate any other type of behaviour, as shown in the figure. The higher percentage of respondents not using ACs during the MCO period was evident from those who did not use ACs at the office before the MCO period. Previous AC users tended to use ACs while remote working during the MCO period more than previous non-users. The statistical significance of these differences was evident from the non-overlapping error bars. High-rise building dwellers were found to show a higher tendency not to use ACs and a lower tendency always to use ACs while working remotely, compared to the residents of other types of buildings, and these differences were statistically significant. The significant association between the working room and AC-usage behaviour during the MCO period is mostly captured by those who did not use ACs during remote work. This category contained a significantly higher percentage of respondents who worked remotely in the communal spaces of their houses during the MCO period than those who worked in private rooms. Respondents from the low-income group tended not to use ACs during remote work than high-income respondents and those who preferred not to reveal their monthly household income. The low-income group contributed to a significantly lower percentage of always using ACs during the MCO period compared to the respondents from the high-income and unexposed groups. The figure illustrates that the respondents with low electricity bills showed a higher reluctance to use ACs and a lower tendency to always use ACs during the MCO period than those from all the other categories (medium, high, and unknown). A significantly higher percentage of always using ACs during the MCO period is shown for respondents with high electricity bills, compared to the low and medium categories. Both the middle-aged and older respondents revealed significantly higher reluctance to AC use during the MCO period than younger participants, although no significant difference is evident for the “always used” behaviour amongst these three age groups. Males were found to have a significantly higher percentage of rarely using ACs during the MCO period than their female counterparts. A significantly higher tendency towards rare AC use was projected for Malay people than for other ethnicities during this period.

The bivariate analysis was followed by a regression analysis using a suitable ORL—able to handle ordinal response variables with \( > 2 \) categories (McCullagh, 1980)—to examine the fitted associations between the selected covariates and the response variable. Since the response variable, AC-usage behaviour during the MCO period, is a categorical variable with four levels—and because a sense of order is inherent amongst these levels—it was analysed using the ORL. Covariates were included in the regression model, which sequentially accounted for the extent of their importance. Previous behaviour-related covariates were identified as the most important because of the substantial association between habitual behaviours, thermal comfort actions, and energy consumption (Huebner et al., 2013). Hence, AC usage at the office before the MCO period was analysed first. Subsequently, the well-established relationship between indoor thermal comfort and building spaces and characteristics (Adunola and Ajibola, 2016) motivated this study to focus on dwelling conditions. Thus, the covariates of residential house type and working room at home during MCO were prioritised. Next, the ORL assessed the association
between new AC-usage behaviour during the MCO period and the economic situations or conditions that could constrain the respondents’ AC usage. Finally, demographic characteristics, such as age group, gender, and ethnicity, were analysed along with other covariates. The purpose of such analyses was to identify the group that was more likely to avoid and adopt AC use during remote work. Thus, 1873 complete observations on all the selected variables, after discarding the missing values, were analysed using four different ORs. The first model (Model 1) contained only previous behaviour-related covariates. The dwelling conditions were incorporated in Model 2, while the third model (Model 3) encompassed the variables related to previous behaviour, dwelling conditions, and economic conditions. Finally, in Model 4, all selected covariates were included as the variance inflation factor for each covariate was observed to be below 5, indicating no multicollinearity amongst these covariates (Shrestha, 2020). The results of these models are listed in Table 2, showing the ORs and p values to indicate the statistical significance of the corresponding effect.

According to the results obtained from the final model (Model 4), all the covariates, except for residential house type and gender, were significantly associated with the response of interest. As this model included all covariates, it was considered as the final model and interpreted. While interpreting the OR of a variable, all other covariates were considered to be at a specific level.

One of the most important covariates, AC-usage behaviour at the office before the MCO period, was found to be significantly and negatively associated with AC-usage behaviour in remote work. The OR indicates that the odd of not using ACs while working remotely during the MCO period was \((1 - 0.28) \times 100\% = 72\%\) lower amongst those who previously used ACs at the office than amongst the previous non-users. This implies a higher likelihood of AC use during the MCO period for previous AC users than for their counterparts. Thus, the persistence of habitual behaviour (Kurz et al., 2015) regarding AC use is highlighted, connecting the working periods before and during the MCO period. While residential house type was not significant in the final model, it is worth noting the possible reasons why it was a significant determinant of AC-usage behaviour during remote work in Model 2. According to this model, the high-rise building dwellers had significantly \((1.46 - 1) \times 100\% = 46\%\) higher odds of not using ACs during the MCO period than those from other types of houses. High-rise buildings are usually well equipped with sufficient ventilation, en-
able fresh air to pass through rooms with higher outdoor velocity and making the rooms cooler than those of low-rise buildings (Aflaki et al., 2014). Consequently, the inhabitants of high-rise buildings can more easily achieve the desired level of thermal comfort without using ACs during remote work. Furthermore, the security and privacy of apartments allow female workers to work without wearing hijabs, which may also have contributed to the lower AC use of high-rise building residents during the MCO period. Another influential factor was the working room at home during the MCO period because of its significant association with AC-use behaviour in remote work. The OR for the private room users is 0.25 (< 1), which indicates less likelihood of not using ACs while working remotely in the private rooms of the houses compared to those who used communal spaces for remote work. The higher reluctance in AC use amongst the users of communal spaces is attributable to the openness and comfort of these places of a house, compared to bedrooms or study rooms. Consequently, a higher percentage of AC installations was exhibited in bedrooms than in communal spaces, such as living areas or dining rooms by Kubota et al. (Kubota et al., 2021). In general, rooms with larger floor areas and better natural ventilation can potentially increase indoor wind speed, resulting in the mitigation of the thermal discomfort of occupants. Thus, people can work comfortably without using ACs in the communal spaces of their houses. Moreover, AC use in these more spacious communal spaces requires a large cooling capacity which results in a higher electricity bill. Hence, communal space users were more reluctant to use ACs while working remotely during the MCO period.

Both covariates related to economic conditions appeared to be significant factors for new behaviour. The ORs for the high-income group and those who did not expose their income were 0.51 and 0.57, respectively, with p values less than 0.001. Since both the ORs are significant and less than 1, the respondents from these two groups were less likely not to use ACs while working remotely than those with a medium-income level. No such significant association was observed between the low- and medium-income groups, which may be surprising. This is because the low-income group would have been presumed to show higher reluctance towards AC use during the MCO period owing to pandemic-day economic problems. This result can be explained by the policy implementations of the Malaysian government regarding economic stimulus packages to support residents during the strenuous MCO pe-

| Table 2 | Results of ORs presenting the ORs and p values. |
|-----------------------------|---------------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| Covariates                  | Model 1                         | Model 2                     | Model 3                     | Model 4                     |                            |
|                            | OR     p value                   | OR     p value               | OR     p value               | OR     p value               |                            |
| Intercept 1                 | 0.09   < 0.001                   | 0.04   < 0.001               | 0.04   < 0.001               | 0.04   < 0.001               |                            |
| Intercept 2                 | 0.18   < 0.001                   | 0.08   < 0.001               | 0.08   < 0.001               | 0.09   < 0.001               |                            |
| Intercept 3                 | 0.36   < 0.001                   | 0.17   < 0.001               | 0.17   < 0.001               | 0.19   < 0.001               |                            |
| Previous Behaviour          |                                  |                            |                            |                            |                            |
| AC usage at the office before the MCO period |                            |                            |                            |                            |                            |
| Not used (RC)               | -      -                          | -      -                      | -      -                      | -      -                      |                            |
| Used                        | 0.36   < 0.001                   | 0.27   < 0.001               | 0.28   < 0.001               | 0.28   < 0.001               |                            |
| Dwelling Conditions         |                                  |                            |                            |                            |                            |
| Residential house type      |                                  |                            |                            |                            |                            |
| High-rise buildings         | 1.46   0.005                     | 1.31   0.054                 | 1.16   0.31                  |                            |                            |
| Others (RC)                 | -      -                          | -      -                      | -      -                      | -      -                      |                            |
| Working room at home during MCO |                                  |                            |                            |                            |                            |
| Communal spaces (RC)        |                                  |                            |                            |                            |                            |
| Private rooms               | 0.25   < 0.001                   | 0.29   < 0.001               | 0.29   < 0.001               |                            |                            |
| Economic Conditions         |                                  |                            |                            |                            |                            |
| Monthly household income    |                                  |                            |                            |                            |                            |
| Low income                  | 0.96   0.73                      | 0.96   0.75                  | 0.51   < 0.001               | 0.45   < 0.001               |                            |
| Medium income (RC)          | -      -                          | -      -                      | -      -                      | -      -                      |                            |
| High income                 | 0.51   < 0.001                   | 0.45   < 0.001               | 0.63   0.003                 |                            |                            |
| Not exposed                 | 0.57   < 0.001                   | 0.63   0.003                 |                            |                            |                            |
| Monthly household electricity bill |                                  |                            |                            |                            |                            |
| Low                         | 2.21   < 0.001                   | 2.25   < 0.001               |                            |                            |                            |
| Medium (RC)                 | -      -                          | -      -                      |                            |                            |                            |
| High                        | 1.53   0.06                      | 1.55   0.053                 |                            |                            |                            |
| Unknown                     | 1.09   0.78                      | 1.39   0.300                 |                            |                            |                            |
| Demographic Characteristics |                                  |                            |                            |                            |                            |
| Age group                   |                                  |                            |                            |                            |                            |
| Young (RC)                  | -      -                          | -      -                      |                            |                            |                            |
| Middle-aged                 | 0.53   0.003                     | 0.48   0.002                 |                            |                            |                            |
| Older                       | 0.48   0.002                     |                            |                            |                            |                            |
| Gender                      |                                  |                            |                            |                            |                            |
| Female (RC)                 | -      -                          | -      -                      |                            |                            |                            |
| Male                        | 1.08   0.480                     |                            |                            |                            |                            |
| Ethnicity                   |                                  |                            |                            |                            |                            |
| Malay                       | 2.23   < 0.001                   |                            |                            |                            |                            |
| Others (RC)                 | -      -                          |                            |                            |                            |                            |
| RC: Reference category.     |                                  |                            |                            |                            |                            |
riod. One of these important packages was the Bantuan Prihatin Nasional (BPN) package [Kriteria Kelayakan Bantuan Prihatin Nasional [Internet] 2021], provided to people with low- and medium-income levels. The low-income group received a higher amount of aid than the medium-income group through this package. The association between the medium- and high-income groups is obvious, as people with high income did not need to worry about the electricity bill and compromise their comfort by scaling down AC use during the MCO period. In the case of monthly household electricity bills, people with low electricity bills had a significantly higher possibility (OR = 2.25, p < 0.001) of not using ACs during the MCO period than those with medium electricity bills. No other groups of this covariate were found to have any significant association with AC-usage behaviour in remote work. Despite the government and TNB designing various packages, such as electricity discounts under the economic stimulus packages and BPE (BERNAMA 2020), people with low electricity bills confined themselves to limited AC use during this period. The reason is that most of these people (63.27%) belonged to the low-income group, according to the bivariate analysis results. Thus, they were more reluctant to use ACs during remote work, being vulnerable to lower salaries and job insecurity (Sharudin, 2020).

Middle-aged and older working people revealed significantly (1 – 0.53) × 100% = 47% and (1 – 0.48) × 100% = 52%, respectively, lower odds of not using ACs during the MCO period than those from the young age groups. This can be attributed to the pandemic-induced financial crisis, which has been more adverse for young Malaysian workers, alongside the deterioration of the theroregulatory system with ageing (Inoue and Shibasaki, 1996()). Malaysian youth are enduring a catastrophic situation with higher under-employment and salary reductions (Aun and Zhang, 2021). This situation impeded the MCO-day AC use of young Malaysian employees. Another significant OR was found for the Malay people, which was 2.23. Since the OR is greater than 1, the Malay people were significantly more likely to not use ACs during this period compared to working people of other ethnicities.

4.2. Changes in AC-Usage behaviour due to MCO implementation

To analyse changes in AC usage at work due to implementation of the MCO, a new response variable was created by combining two variables: AC-usage behaviour during the MCO period and AC-usage at the office before the MCO period. In the first of these, the responses on AC-usage behaviour during remote work (from 5076 participants) were recategorized. The categories “not used” and “rarely used” were combined to become “not used”, and “sometimes used” and “always used” were combined into another new category, “used”. When this recategorized AC-usage behaviour during the MCO period was combined with AC usage at the office before the MCO period (including the answers of 2772 respondents), only two of the four possible combinations represented behavioural changes:

- used AC at the office before the MCO period, but did not use it during the MCO period, and
- did not use AC at the office before the MCO period but used it during the MCO period.

These two types of changes were renamed “stopped AC use during MCO” and “started AC use during MCO”, respectively. The remaining two combinations indicated no change in AC-usage behaviour and were termed “no change”. Thus, a new variable, named change in AC use, with three categories (no change, stopped AC use during MCO, started AC use during MCO) was constructed to project behavioural changes in AC use. This new variable comprised 2772 individual responses. To identify the potential determinants of these changes in AC-usage behaviour, all the covariates except “AC usage at the office before MCO” were analysed (as this variable was already used in the calculation of the corresponding response variable). The bivariate analysis of changes in AC-usage behaviour is presented in Fig. 3, displaying bar charts along with the p values of the chi-square test of independence.

The bivariate analysis of the change in AC usage during the MCO period shows the largest ratio in the no-change category in most cases. Amongst the two types of behavioural changes, the dominance of the change “stopped AC use during MCO” over “started AC use during MCO” is evident from all the bar charts used for bivariate analysis. The results of the bivariate analysis are discussed below, focusing on salient differences in the percent-ages of changes for the corresponding categories of the covariates. High-rise building dwellers tended to stop using ACs during the MCO period compared to the residents of non-high-rise buildings. A higher percentage of stopping AC use during the MCO period emerged for respondents who used the communal spaces of their houses for remote working, compared to private room users. People in the medium-income group showed a significantly higher tendency to stop AC use during the MCO period than those at any other income level. The start of AC use during the MCO period soared amongst high-income respondents, compared to those with low- and medium-income levels. Respondents with high electricity bills stopped using ACs to a greater extent than did all the other groups. The starting AC use during the MCO period was most common for the respondents unfamiliar with their monthly electricity bill. Middle-aged working people tended to both stop and start using ACs during this period, with a higher percentage than those from the young group. AC use during the MCO period was started more frequently by male participants than their female counterparts. Malay people tended to stop using ACs while working remotely during the MCO period compared to other ethnic groups. An inverse relationship was found for starting AC use. The p values indicate the statistical significance of all the selected covariates, which permitted the inclusion of all covariates in the regression model for further analysis.

Bivariate analyses triggered significant associations between the outcome variable and covariates. The plausibility of these associations was required to be analysed, accounting for all the covariates. To this end, an MLT was used. The total number of observations included in this analysis was 1873 after discarding the missing values of the considered variables. The applicability of the MLT for analysing unordered outcome variables with more than two categories (Bayaga, 2001) motivated us to adopt this regression model in this section. This is because the response variable of interest is a categorical variable with three levels that cannot be ordered. In this model, respondents who reported no change in their AC-usage behaviour in remote work during the MCO period were used as the reference category. This means that two specific models were obtained for those who stopped and started using ACs during the MCO period, and the results of both models were comparable to the no-change category. Table 3 shows the results of these models, presenting the RRRs and p values, to check the statistical significance of the effects.

The cessation of AC use during the MCO period, using it at the office before the MCO implementation but not during remote work, encountered significant associations with all the covariates, except residential house type and gender. By contrast, the model for starting AC use during the MCO period (using ACs while working remotely but not at the office before the MCO period) confirmed the statistical significance of all covariates, except for residential house type and age group. In the case of working rooms at home during the MCO period, the RRRs for stopping and starting AC use during this period were 0.287 and 0.527, respectively, which were statistically significant. Since these RRRs are less than 1, the changes rel-
ative to not changing behaviour were \((1 - 0.287) \times 100\% = 71.3\%\) and \((1 - 0.527) \times 100\% = 47.3\%\) less likely for the users of private rooms than those of the communal spaces. This implies that people who used communal spaces in their houses for remote working were prone to both types of changes in AC-usage behaviour concerning the non-changing group. Communal spaces, which are usually more open and wider than private rooms, should be comfortable without AC. Additionally, AC use in these wide rooms requires a large cooling capacity and higher electricity bills. Hence, Malaysian people install ACs in private rooms more often than in communal spaces, such as living areas or dining rooms (Kubota et al., 2021). Therefore, people working remotely in communal spaces, accustomed to using ACs at the office, could easily curb AC use during the MCO period. This finding was also supported by the results of the bivariate analysis, with 49.28% of common room users ceasing to use ACs during the MCO period. This number was significantly higher than that for users of private rooms (22.34%). However, according to the regression model, people who did not use ACs at the office before the MCO period were more likely to start AC use it during this period, relative to the no-change group, when working remotely in communal spaces. The bivariate analysis results showed that both the common room and private room users had similar percentages for the start of AC use during remote work, which were 5.61% and 6.11%, respectively. By contrast, the no-change category exhibited a substantial difference in the percentage values. A significantly higher percentage (71.56%) of the respondents who worked remotely in private rooms of their houses did not change their AC-usage behaviour compared to the users of communal spaces (45.11%). Due to higher comfort levels and cost issues, many communal space users halted AC use while working remotely during the MCO period. Thus, the difference in the percentages of the no-change category contributed to a higher possibility of starting AC use during the MCO period for communal space users compared to the users of private rooms.

Compared to the medium-income group, people with low- and high-income levels had \((1 - 0.353) \times 100\% = 64.70\%\) and \((1 - 0.351) \times 100\% = 64.90\%\) lower likelihood of stopping AC use during the MCO period relative to the no-change group. These findings were statistically significant, as the \(p\) values were less than 0.05. In the case of starting AC use during this period, a significantly lower possibility (with RRR = 0.495 and \(p = 0.014\)) was exhibited for the low-income group compared to those with...
medium incomes. Through government allowances such as BPN (Kriteria Kelayakan Bantuan Prihatin Nasional [Internet] 2021) and discounts on electricity bills under economic stimulus packages and BPE (BERNAMA 2020), the low-income group received higher support from the government than did those with medium incomes. Consequently, the catastrophic situation during the MCO period did not considerably dissuade the low-income group from using ACs and working comfortably in remote work. At the same time, on the grounds of these subsidies, low-income people who were not used to AC consumption at the office before MCO could not rationally start using it during the MCO period. People with high incomes can easily afford AC use during the MCO period. Hence, they were less inclined to halt AC use during remote work while habituated to it at the office prior to MCO. The significant RRR of stopping AC use during the MCO period was found only for people with high electricity bills for the monthly household electricity bill. This implies that people from this group, compared to those with medium electricity bills, were more likely (with RRR = 2.215) to stop using ACs in remote work during the MCO period relative to no change in AC-useage behaviour. The Malaysian government and TNB provided BPE as an additional discount to all domestic customers of TNB, which was specifically designed for the 3-month MCO period. With this package, monthly household electricity bills up to MYR 77 (USD 18.57) were completely free, and electricity consumption between 601 and 900 kWh (MYR 395.60 or USD 95.41) received an additional 8% discount. Thus, the gap between the low (< MYR 100 or USD 24.12) and medium- (from MYR 101 to MYR 400 or from USD 24.36 to USD 96.47) level electricity bills was not significant for stopping AC use during the MCO period. The high electricity bill group had to scale down their AC use during the MCO period to cope with the situation. For the start of AC use during the MCO period, the respondents unfamiliar with their electricity bill were found to have an RRR of 4.906, which is greater than 1 and statistically significant. Hence, the likelihood of starting AC use during the MCO period relative to the no-change group was significantly higher than those who belonged to the medium-bill group. Thus, AC use in remote work was unconsciously adopted by people who were not accustomed to AC use at the office preceding the MCO days. Compared to the young working people, middle-aged and older employees had (1 − 0.176) × 100% = 82.40% and (1 − 0.113) × 100% = 88.70% lower likelihood of stopping AC use concerning not changing behaviour during the MCO period. These differences in the RRRs were statistically significant. The reason might be that the pandemic was more hostile to the young generation of Malaysian working people because of the higher risk of under-employment and declining earnings (Aun and Zhang, 2021). In addition, male participants exhibited a significant RRR of 1.971 for starting AC use during the MCO period. Hence, this type of change was more likely to occur amongst male working people than amongst their female counterparts. The International Labour Organization (ILOMonitor, 2021) reported that women worldwide were more vulnerable to employment loss and job insecurity than men during the pandemic. This unfavourable situation might have discouraged them from using ACs while working remotely amongst those not used to ACs before the MCO period. Malay participants, compared with other ethnic groups, were significantly more likely to stop (RRR = 2.849, p < 0.001) and less likely to start (RRR = 0.543, p = 0.021) using ACs during the MCO period relative to the no-change category. This implies that Malay respondents adapted to the pandemic and MCO restrictions with minimal use of AC while working remotely.
4.3. Reasons for behavioural change

The sections presented earlier analysed different characteristics of people and depicted specific population groups who had a greater or lesser inclination to curb AC use during the MCO period. However, it is also necessary to envisage peoples’ perspectives scrutinising the factors that aroused the MCO-day transition in AC-usage behaviour. Therefore, this section illustrates why Malaysian people increased or decreased AC use during remote work. The participants’ thermal sensitivity as well as their outlook and attitude towards governmental aid or discounts are also discussed, which can be decisive for policy makers and program managers. Table 4 displays the varying reasons for using and not using ACs while working remotely during the MCO period in Malaysia.

The table shows that the highest percentage (82%) of AC use during this period was for discomfort-related reasons. Only a few respondents (8.75%) were found to use their ACs at this time, owing to support from the government or TNB. The reasons other than discomfort and aid comprised only 9.25% of the respondents. These findings highlight the dominance of sensation-related reasons over all other reasons for using ACs in remote work during the MCO period. The discomfort caused by the extremely hot and humid climate of Malaysia might have outweighed the impact of finance-driven responses.

On the contrary, amongst the reasons for not using ACs during remote work, the highest response (39.53% of respondents) was obtained for ceiling fans or natural ventilation. A high electricity bill secured the second-highest position selected by 25.13% of participants. This part of the analysis uncovered several other reasons for not using ACs during this time, including acceptable indoor temperature (11.64%), common behaviour or habit (9.96%), and other reasons (13.75%). Thus, the pandemic-induced high household electricity bill discouraged people from using ACs and shaped their common practices regarding the use of cooling appliances. Furthermore, the highest percentage of respondents preferred not to use ACs because they preferred ceiling fans and natural ventilation. This indicates that Malaysian people were adopting an energy-saving lifestyle, moved by their preferences and willingness along with the increase in electricity bills during the MCO period. Some responses were also captured by habitual behaviour and acceptance of indoor thermal conditions. This finding suggests the existence of some Malaysian people who have already been habituated to work without ACs and find an in-house thermal environment tolerable without AC. In summary, this section recognised some important factors relating to participants’ increased or reduced AC usage in remote work. This knowledge may be of great benefit to policy makers in designing programs to increase eco-friendly lifestyle awareness, and in promoting building designs which incorporate thermal properties suitable for improving indoor thermal comfort.

This study reveals how this new evolving behaviour of AC-related electricity consumption can contribute to energy sustainability in Malaysia. The rapid infrastructure development and economic progress of Malaysia have resulted in a boost in energy demand. Hence, researchers are motivated to determine various renewable energy sources (Maulud and Saidi, 2012; Abdullah et al., 2019; Shamsuddin, 2012) to reduce fossil fuel consumption. To ensure sustainable energy for future generations, the efficient use of electricity in buildings has already been promoted, and energy conservation behaviour has been encouraged in previous studies (Shaikh et al., 2017; Ting et al., 2011). Another imperative research field for reducing the cooling load of buildings is to analyse the envelope design through passive strategies, which is also popular in Malaysia (Mirrahimi et al., 2016; Al-Tamimi and Fadzil, 2012; NAM, 2010). The building envelope was found to be the most important design parameter for achieving thermal comfort and energy efficiency in urban high-rise buildings in Malaysia (Mirrahimi et al., 2016). However, significant transformation is difficult to achieve in energy and electricity consumption behaviour without policy implications (Ahborg et al., 2015; Edomah et al., 2017). A more challenging situation appears when a behavioural change pertains to a permanent usage pattern (Edomah and Nduue, 2020). To this end, the current study analysed the potential factors behind these MCO-driven changes to AC-usage behaviour and changes in AC use, with a view to informing policy makers in designing and implementing their programs. In this way, the residents can be habituated to the rational use of AC.

4.4. Practical implications

The findings of this work highlighted various aspects of the AC-usage behaviour of Malaysian people, revealing their characteristics. Based on these characteristics, some practical implications are made to prevent abundant AC use behaviour and sustain the energy sector of Malaysia. First, people should be encouraged to work remotely in the communal spaces of their houses using natural ventilation or ceiling fans. Advertisements or campaigns should focus on people accustomed to AC use at the office before the MCO period to motivate limited AC use. Economic stimulus packages should be accompanied by small incentives to reward reductions in AC use during the MCO period. Thus, the preference for ceiling fans or natural ventilation, the most prominent reason for not using ACs in remote work, can be expedited to enact the habit of energy sustainability which may persist for many years. These incentives should be promoted frequently through mass media to attract people, especially those with low- and medium-level incomes. Thus, they can be encouraged to reduce their use of ACs despite the economic stimulus packages and discounts on electricity bills. Different aid from the Malaysian government reduced the disparity between the low- and medium-income groups in AC-usage behaviour during the MCO period. People with a low income level received higher amounts of incentives or discounts than those from the medium-income group. Thus, the low-income group was less likely to curb AC use in remote work and compromise their comfort level. Most of the incentives were designed focusing on the MCO period to support the Malaysian people. However, these aids drove people to rely on AC use which may persist after the pandemic. Subsidy-driven AC use has been confirmed by the findings of the reason analysis, which indicated that some participants used ACs while working remotely due to aid or discounts on elec-

Table 4

Reasons for transition in AC-usage behaviour while working remotely during the MCO period.

| Reasons Using AC in Remote Work (800) | Frequency | Percentage |
|-------------------------------------|-----------|------------|
| Discomfort-related reasons          |           |            |
| - Very hot indoor temperature       | 656       | 82.00%     |
| - Very hot outdoor temperature      | 342       |            |
| - Uncomfortable without AC          | 163       |            |
| - Uncomfortable with AC             | 151       |            |
| Aids-related reasons                |           |            |
| - Allowance from government         | 70        | 8.75%      |
| - Discount on electricity bill      | 24        |            |
| Other reasons                       | 74        | 9.25%      |

| Not Using AC in Remote Work (2750) | Frequency | Percentage |
|------------------------------------|-----------|------------|
| Preference for ceiling fan/natural ventilation | 1087     | 39.53%     |
| Rise in electricity bill           | 691       | 25.13%     |
| Acceptable indoor temperature      | 320       | 11.64%     |
| Common behaviour                   | 274       | 9.96%      |
| Other reasons                      | 378       | 13.75%     |
tricity bills. Hence, it is time to refrain from this practice for the upcoming post-pandemic era. The limited use of AC should be popularised amongst people with low incomes as a potential means of energy conservation behaviour. Moreover, the Malaysian government should plan high-rise housing to accommodate low-income people since high-rise buildings are more comfortable without AC. The unconscious and abundant use of AC can be decreased by enhancing awareness amongst people about checking their monthly household electricity bills and acting accordingly. The people who did not know their electricity bill were most likely to start using ACs during remote work, although they did not use it at the office before MCO. Providing the service to monitor household electricity bills easily can facilitate rational energy use behaviours and should be practiced to ensure an energy-efficient lifestyle. Middle-aged and older people should be inspired to be less dependent on ACs and practice other cooling methods. Moreover, alternatives to AC, such as free-standing fans, window fans, evaporative coolers, and geothermal systems, should be introduced and popularised, highlighting the drawbacks of AC use. The redesign and rehabilitation of building envelopes integrating passive strategies are indispensable to reduce AC use. Most of the respondents used ACs during the MCO period because of an uncomfortable thermal environment. It can also potentially decrease the need for varying incentives by lowering the occupants’ demand for electricity. Furthermore, effective policy implications are necessary to reinforce it along with the decarbonisation of the residential sector. Finally, regional and national governments should analyse energy consumption strategies and scenarios during this chaotic time and develop energy policies to withstand any future extreme impacts of climate change. Many studies have substantiated the prominent association between climate change and energy consumption. In this epoch of climate change, the long-term trend of temperature rise has accelerated the need for cooling appliances. The scorching heat of summer elevates the electricity demand for cooling. It can curtail the power-carrying ability of transmission lines and result in grid collapse during heat waves. Thus, the present global climate change necessitates heat adaptation to combat any upcoming temperature rise. One of the key heat resilience strategies is to achieve energy efficiency in daily life and in buildings, which will reduce the cooling demand and increase the reliability of the power grid, especially during heat waves. By contrast, energy efficiency plays a pivotal role in reducing greenhouse gas emissions with lower energy use. Therefore, policies must ensure an energy-efficient lifestyle and reasonable buildings to provide a better indoor environmental. The findings of this study revealed some important characteristics of Malaysian people who practised limited AC use during this pandemic. Based on the analyses, some recommendations have also been made specifying the population groups that need to be focused on promoting curbed AC use. Some policy implications have also been discussed. These policy implications are paramount to attain an energy conservation lifestyle by limiting AC use, essential for future extreme climate events.

4.5. Limitation and Future Scope

One of the limitations of this study was that it did not analyse home composition (orientation of the building), surface area of the house, number of rooms, presence or absence of any energy-efficient elements, number of occupants sharing the space, telestudents sharing device or workspace, telework space flexibility in caregiving responsibilities for the youngest, difference in electricity bills due to MCO enforcement, socioeconomic status, and job profiles of the teleworkers. These factors may affect the AC-usage pattern while working remotely during the MCO period and should be the focus of future studies. Second, the analysis procedure, comprising only the urban people of Malaysia who worked remotely from home during the MCO period and could afford AC use at home, did not scrutinise issues such as hidden energy poverty. This is because most of the analysed communities had stable energy access in terms of both energy supply facilities and financial conditions. Thus, there is probably no need to consider this energy poverty concept in this study. However, further application of these analytical approaches in other geographic regions, not only in Malaysia but also throughout the world, should account for energy poverty, if necessary. Next, this study did not analyse meteorological conditions, such as daily temperature and relative humidity. Malaysia is a country with a yearlong summer where the daily weather conditions of the MCO period cannot be distinguished from other times of the year. This might not be the case for any other geographical area. Therefore, if the analytical procedure of this study will be performed focusing on other regions of the world, meteorological factors should be examined. Moreover, the findings of this study cannot be generalised to the entire population of Malaysia, as it sampled distinct Malaysian people in terms of MCO work status and AC ownership.

Further studies are required to investigate whether this new practice of AC use prevailed under varying levels of MCOs, such as the conditional MCO, recovery MCO, enhanced MCO, targeted enhanced MCO, and administrative enhanced MCO, which produced fluctuations in the extent of restrictions. If the proposed actions to curb AC use during subsequent MCOs, along with the upcoming unrestricted conditions, are implemented, the productivity of these actions should also be examined in future studies. Furthermore, any future crisis, which can be climatic, substantiates the importance of further studies to analyse the consequences of extreme temperatures.

5. Conclusions

This study projected whether mass enforcement of movement restrictions could change the thermal adaptation behaviour of workers utilising AC usage and determine the characteristics of workers who adopted such changes. This work has also discussed how these behavioural changes can be harnessed to develop a new pattern of AC use instigating energy conservation behaviour. However, both the government and policymakers need to re-evaluate their strategies and programmes to modify the energy sector to attain the goal of energy sustainability. The findings of this study will facilitate policy implications by identifying the characteristics of people to be emphasised and different means of capturing the controlled use of AC. Thus, this study contributes to ensuring a sustainable future for the energy sector in Malaysia. Government stimulus packages and electricity discounts removed the financial gap between low- and medium-income groups, and thereby erased any difference in changes of their AC-usage behaviours. In light of this finding, policymakers can design strategies to attract people towards energy-saving lifestyles through special rewards or small incentives. In this way, the practice of energy conservation behaviour may evolve as a new habit to prevail even after the pandemic. Furthermore, the importance of the service enabling easy checking of the household electricity bill should be highlighted through varying advertisements or educational campaigns to decrease the unconscious use of AC. The fruitfulness of the new strategies can be scrutinised by future studies focusing on varying levels of MCOs and the post-MCO period in Malaysia. Moreover, frequent investigation into this field will advocate whether the MCO could establish a new perspective in attaining energy sustainability and, if so, how long an energy-efficient lifestyle may prevail.

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