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Final Report

Project No.: 2021.A7.021.21C

THE PERSISTENCE OF BEHAVIORAL CHANGES IN POST-PANDEMIC HONG KONG: IMPLICATIONS FOR TRANSPORTATION, HOUSING & ECONOMIC DEVELOPMENT POLICIES

後疫情時代香港社會行為轉變的持續性研究：對於交通政策、住房政策 以及經濟發展政策的指導意義

ABSTRACT

The global scourge of the COVID-19 pandemic has vastly reshaped everyday behavior, possibly in enduring ways. If they persist, behaviors popularized by the pandemic, such as working from home and online shopping, may impact economic development and urban policies in the years to come. Such behaviors could, for instance, boost the growth of more peripheral locations and reduce the tendency towards concentrated growth in central city areas. Thus, they could theoretically depress home prices in dense urban areas. Meanwhile, such behaviors could also have deleterious effects on the traditional retail sector while spurring growth in the e-commerce and delivery service sectors. Understanding these changes and the likelihood of the persistence of different behaviors in the wake of the pandemic can contribute to more informed policymaking in economic development, transportation, housing, and other relevant areas to meet the needs of a post-pandemic era.

To aid in this understanding, this study utilizes the survey infrastructure of the Hong Kong Panel Study of Social Dynamics (HKPSSD) to conduct a timely population-representative survey of Hong Kong households as the pandemic recedes, collecting data on behavioral patterns before, during, and immediately after the pandemic. Based on the survey results, we explore the following four research topics:

- **Descriptive statistics:** Examine the return of COVID-19-affected behaviors to pre-pandemic norms over an 18-month period through surveys and empirical data collection.
- **Behavioral Change Analysis:** Investigate the reasons for behavioral changes during and after COVID-19, focusing on the mediating effects of economic circumstances, access to technology, shifts in attitudes and values, and stress levels.
- **Predictive Modeling:** Utilize a model to forecast the likelihood of the persistence of these behavioral changes based on observed patterns and the impact of various intervening variables.
- **Demographic Variability:** Analyze how the persistence of these behaviors varies across different population segments.

Our key findings include: 1) the prevalence of teleworking, although not as expected, is forecast to remain significantly higher in the future than it was before the pandemic, especially for the highly educated and high-income groups; 2) the transportation choices of Hong Kong residents remained relatively stable in the pre-pandemic, mid- and post-pandemic periods, with public transportation remaining the most important mode, with lower-income groups choosing to walk more often at the peak of the pandemic, while higher-income groups are more likely to use private cars; 3) dine-in behaviors are still in the process of recovering, with pick-ups and take-aways becoming the alternative, and are expected to become the new normal; and 4) online shopping and e-payments will continue to grow in the post-pandemic period.

SUMMARY ON POLICY IMPLICATIONS & RECOMMENDATIONS

We examine behavioral changes pertaining to travel, work, shopping, and housing choices. As such behavioral changes may be caused not only by immediate health risks and government-imposed restrictions stemming from the pandemic, but also by mediating factors such as economic contraction, investment in technology and improvement in technological skills, changes in attitudes and values, or stress, this survey also investigates changes in these intervening variables during and after the pandemic. In this preliminary descriptive phase, our principal observations are as follows: 1) the prevalence of telecommuting cannot persist in Hong Kong; 2) public transport remains the dominant mode of transport, but its proportion of trips for non-commuting purposes has declined significantly; 3) The growth in food pick-up, food delivery, online shopping, and e-payment; 4) A more prudent view of consumption; and 5) The rise in psychological stress has an exceptionally strong stickiness.

Moreover, this study leverages the Structural Equation Model (SEM) to examine how behavioral changes are mediated by the above factors. Understanding the relationship between behavioral changes and different mediating factors allows us to draw inferences about the likelihood of behavioral patterns lasting beyond the pandemic. For example, behavioral changes primarily correlated with pandemic-induced stress are likely to fade quickly after the pandemic recedes, or even during its later phases as the population adapts to the new normal. On the other hand, behavioral changes associated with changes in access to technology are likely to persist in the long term.

Based on SEM models, the study finds that stress level, access to technology, and attitudes/values indeed have mediated the impacts of COVID-19 health risks and economic situation on peoples' behavior changes. It finds that living in a neighborhood with more confirmed COVID-19 cases has enhanced crowdedness aversion. It's also revealed that a higher stress level growth rate during the pandemic is more attributed to a limping economic situation, yet less influenced by objective COVID risks in the neighborhood. In general, a bigger change in stress levels, increase in crowd aversion, preference for videocalls and increasing access to technology discourage visits to crowded places or outdoor activities and increase online activities.

Based on the t-tests for comparing the difference between T1 and T4, and the SEM results, the study predicts that in the post-pandemic period, there will be a higher rate of take-away and online grocery orders, more frequent working-from-home practices, and a lower public transit usage for daily travel. The study also notes that the magnitudes of changes in travel-related behavior are smaller than those in catering and consumption behaviors, possibly due to the less elasticity of modal shift and lack of travel mode choices in Hong Kong due to its transit-oriented urban designs. In summary, the study highlights the significant influence of economic circumstances, stress levels, attitudes and values, and technology accessibility on people's behavior changes during

the pandemic and provides insights into the potential lasting impacts of these changes in the post-pandemic period.

This study also reveals that persistence in behavioral changes following the pandemic varies among Hong Kong residents across different income and education levels. Specifically, individuals with higher income and education levels have more enduring work-from-home (WFH) and online meeting habits, with the highly educated showing greater long-term adoption of online meetings than their high-income counterparts. Conversely, the low-education group has largely reverted to pre-pandemic levels in online meeting participation, indicating a lack of lasting change and potential obstacles in accessing these digital advancements. In terms of transportation for commuting, income significantly influences the choice between walking and private car use, with individuals with lower education more frequently walking, possibly due to limited means for private transportation. For non-work travel, both low-income and low-education groups demonstrate consistent transport preferences, suggesting constrained alternatives and possibly insufficient access to safer, private modes of transport during the peak of the pandemic.

The study underscores the necessity for the Hong Kong Government to implement a range of policy recommendations to meet the post-pandemic needs of its residents and economy:

- *Optimizing the configuration of urban spaces and enhancing digital infrastructure to accommodate the growing demand for telecommuting:* Government should consider reconfiguring urban spaces by setting up public telecommuting spaces in existing residential areas with high demand and reserving space for teleworking in future residential planning for the northern metropolitan area. Additionally, the government needs to strengthen digital infrastructure by extending high-speed broadband coverage, accelerating 5G deployment, supporting the development of local collaboration software, and providing training to help enterprises and employees efficiently use telecommuting tools.
- *Ensuring the safety and attractiveness of public transportation during future pandemics, especially to protect the health and safety of low-income groups:* Government should invest in the public transportation system to ensure its attractiveness and efficiency, as it remains the main mode of commuting for residents, especially low-income groups. To reduce the risk of infection in public transportation during future pandemics, the government can adopt innovative measures such as enhancing cleaning and disinfection frequency, upgrading ventilation systems, promoting contactless technology, managing passenger density, and strengthening health monitoring and information dissemination.
- *Supporting Diverse Transportation Needs Amid Changing Travel Preferences:* Government should adapt to residents' diverse transportation choices by improving walking and cycling infrastructure, resolving legal disputes over ride-hailing services, and ensuring the safety and convenience of taxi and ride-hailing services through measures such as promoting contactless payments and adopting dynamic pricing mechanisms.

- *Support for Food and Retail Services:* Policies should facilitate seamless pick-up services and promote digital literacy to bridge the online consumption gap. Additionally, support for retail and food services to adapt to new norms, such as digital payments, is crucial.
- *Mental Health Prioritization:* With the pandemic's lasting psychological impact, mental health services should be enhanced, and initiatives focused on stress reduction and community resilience should be introduced.
- *Financial Support for Economic Stability:* Financial assistance targeting low-income households can help mitigate stress and stabilize consumption patterns, contributing to the city's economic vitality.

These policies aim to create a resilient, adaptable, and sustainable urban environment in Hong Kong, leveraging proactive, forward-thinking, and inclusive strategies for a stronger post-pandemic recovery.

摘要

在過去的幾年中，由新冠疫情引發的全球性災難極大地改變了人們的日常行為。若諸如居家辦公或網上購物等成爲長期現象，未來幾年的經濟和城市將受到影響。例如小城鎮加快發展，而大城市的集中化趨勢減緩同時房價降低。本研究基於香港社會動態追蹤調查的問卷結構對香港家庭進行調查。基於問卷調查結果，我們的研究項目詳細探討了以下四個研究課題：

- **描述性統計：** 通過調查和實證數據收集，研究受 COVID-19 影響的行為在 18 個月內恢復到流行前標準的情況。
- **行為變化分析：** 調查 COVID-19 期間和之後行為變化的原因，重點關注經濟環境、技術獲取、態度和價值觀轉變以及壓力水平的中介效應。
- **模型預測：** 根據觀察到的模式和各種干預變量的影響，利用模型預測這些行為變化持續存在的可能性。
- **人口差異性：** 分析這些行為的持續性在不同人羣中的差異。

我們的主要研究發現包括：1) 遠程工作的普及雖不如預期，但預測仍會較大流行前提升，尤其是對於高學歷及高收入人羣；2) 香港居民的交通選擇在大流行前中後時期都保持相對穩定，公共交通仍然是最重要的方式，低收入人羣在疫情高峯期更多地選擇步行，而高收入人羣則更多地使用私家車；3) 香港居民的堂食行為仍處於恢復之中，而取餐和外賣成為替代，有望成為新常態；4) 網上購物和電子支付將在疫情後持續增長。

政策影響和建議概述

我們關注與交通、工作、購物和住房選擇相關的行為變遷。它們不僅是疫情之下健康風險考量和政策限制的直接結果，同時也可能與經濟、技術、價值觀和壓力等中介因素相關。因此，本研究還探索了這些中介變量在疫情期間和之後的變化。初步描述性觀察包括：1) 在香港，遠程工作的普及不可持續；2) 公共交通仍然是主要交通方式，但非通勤目的的使用比例顯著下降；3) 取餐、外賣、網購和電子支付的增長；4) 更加謹慎的消費觀念；5) 心理壓力的顯著增加。

其後，我們應用結構方程模型來研究行為變遷和不同中介因素之間的關係。例如，主要與疫情壓力相關的行為變化可能會在疫情消退後迅速消失，而與技術應用相關的行為變遷可能會持續到未來。因此我們能夠推斷出哪些行為變遷是可能長期存在的。對這些行爲變遷現象的研究有助於政策制定者在相關領域做出更明智的決策，以滿足後疫情時代的需要。結果顯示，壓力水平、技術訪問和價值觀確實在新冠疫情健康風險和經濟情況對人們行為變化的影響中起到了中介作用。研究發現，居住在新冠確診病例較多的鄰里，會增強對擁擠的回避。在疫情期間，壓力水平增長更多地與經濟狀況不佳有關，與鄰域的客觀 COVID 風險影響較小。一般來說，壓力水平的較大變化、對人群擁擠的回避偏好、視訊通話的偏好以及對技術訪問的增加，會減少對擁擠場所或戶外活動的參與，並增加網上活動。研究預測，在疫情後外賣和網上雜貨訂單的比率將會更高，居家工作的做法將更頻繁，公共交通用於日常出行的使用將降低。研究還指出，與餐飲和消費行爲相比，與出行相關的行爲變化幅度較小，這可能是由於香港的交通導向型城市設計導致出行方式轉變的彈性較小，以及缺乏出行方式選擇。

本研究還揭示了不同收入和教育水平的香港居民在疫情後行爲變化的持續性存在差異。具體而言，收入和教育水平越高的人，其在家辦公和網上會議的習慣越持久，其中高學歷人羣比高收入者更長期採用網上會議。相反，低教育水平人羣的在線會議參與度基本恢復到了流行

前的水平，這表明他們缺乏持久的改變，在使用這些數字進步技術方面存在潛在障礙。在通勤交通方面，收入在很大程度上影響着人們在步行和使用私家車之間的選擇，教育程度較低的人更多地選擇步行，這可能是由於私人交通工具有限。在非工作出行方面，低收入和低學歷羣體都表現出一致的交通偏好，這表明在疫情高峯期，替代交通方式有限，而且可能沒有足夠的機會使用更安全的私人交通工具。

該研究強調，香港政府有必要實施一系列政策建議，以滿足疫情過後香港居民和經濟的需求：

- **優化城市空間配置，加強數字基礎設施建設，以適應日益增長的遠程辦公需求：** 政府應考慮重新配置城市空間，在現有需求較高的住宅區設立公共遠程辦公空間，並在北部都會區未來的住宅規劃中預留遠程辦公空間。此外，政府還需要加強數字基礎設施建設，擴大高速寬帶覆蓋範圍，加快 5G 部署，支持本地協作軟件的開發，並提供培訓，幫助企業和員工高效使用遠程辦公工具。
- **確保未來大流行病期間公共交通的安全性和吸引力，特別是保護低收入羣體的安全：** 政府應投資於公共交通系統，確保其吸引力和效率，因為公共交通仍是居民，尤其是低收入羣體的主要通勤方式。為降低未來流行病期間公共交通的感染風險，政府可採取創新措施，如提高清潔和消毒頻率、升級通風系統、推廣非接觸式技術、管理乘客密度、加強健康監測和信息發布等。
- **在不斷變化的出行偏好中支持多樣化的交通需求：** 政府應適應居民多樣化的交通選擇，改善步行和自行車基礎設施，解決打車服務的法律糾紛，通過推廣非接觸式支付和採用動態定價機制等措施，確保出租車和打車服務的安全性和便利性。
- **支持食品和零售服務：** 相關政策應爲無縫取貨服務提供便利，並促進數字掃盲，以縮小網上消費差距。此外，支持零售和食品服務業適應數字支付等新規範也至關重要。
- **優先關注心理健康：** 鑑於大流行病對心理造成的持久影響，應加強心理健康服務，並推出以減壓和社區復原力爲重點的舉措。
- **爲經濟穩定提供財政支持：** 針對低收入家庭的財政援助有助於減輕壓力和穩定消費模式，從而促進城市的經濟活力。

這些政策旨在爲香港創造一個抗災能力強、適應性強和可持續發展的城市環境，利用積極主動、具有前瞻性思維和包容性的戰略，促進疫後恢復。

Table of Content

I. INTRODUCTION

1.1 Background

With the global outbreak of COVID-19, lives have been reshuffled, and economic and social behaviors have been altered in ways unimaginable just over a year ago. These changes have already had massive ramifications for the economy, from crippling the tourism industry to bolstering the online shopping and home electronics industries. The changes have also markedly affected urban planning and public transportation (Bloom, 2020). A number of studies have examined early-stage behavioral responses to COVID-19, including precautionary behavior (e.g., mask-wearing), travel behavior, and consumption behavior (Abdullah et al., 2020; Bowman et al., 2020; Brinkman & Magnum, 2020; Brough et al., 2020; Laato et al., 2020; Parady, 2020; Qian et al., 2020; Neuberger & Egger, 2020; Shamshiripur, 2020; Zwanka & Buff, 2021; Lee & De Vos, 2023). Some have also examined the pandemic's effects on attitudes such as trust, altruism and pro-social behavior that may have economic implications (Shachat et al., 2020). However, as vaccines are being rolled out and the prospect of an end to the pandemic draws closer, it is vital to understand not just which behavioral changes COVID-19 has induced, but also how "sticky" these behaviors are and the extent to which they will persist in a post-pandemic world. Understanding long-term behavioral changes in work, travel, shopping, and housing choices is important as policymakers amend and design new development plans, such as the *Lantau Tomorrow Vision* and *Northern Metropolis Development Strategy,* to relieve housing shortages and set up corresponding transportation systems. Such an understanding may also help to determine what types of policies (e.g., more subsidies directed at existing sectors such as the Retail Sector Subsidy Scheme, or programs fostering new skills and industries) are most appropriate for stimulating the recovery of an economy that has been severely depressed by over a year of restricted international travel and tourism.

The COVID-19 pandemic is not the first disaster to have dramatically affected human behavior. Terrorist attacks, political and economic crises, natural disasters, and other disease outbreaks all lead to disruptions in regular social and economic behavior. There is a sizable body of literature on how such cataclysmic shocks affect behavior, dealing with both their short-term and long-term effects. The effects of crises on tourism and travel, in particular, have been extensively examined (Lai & Lu, 2005; Lee et al., 2005; Mao et al., 2010; Min, 2005; Valencia & Grouch, 2008). Effects on consumption behavior are another common focus of studies (Cooper, 2013; Debevec et al., 2013; Etzioni, 2011; Kennet-Hensel et al., 2012). While some events have been shown to temporarily affect behavior, others have more lasting effects. Studies of air travel and tourism in the wake of the September 11 terrorist attacks tend to agree that the impact was temporary, although estimates vary on the length of time that the negative shock persisted (Lai & Lu, 2005; Lee et al., 2005). On the other hand, studies have found long-term decreases in spending in the wake of Hurricane Katrina and the persistence

of online shopping behavior in Hong Kong after SARS (Foster & Tang, 2005; Kennett-Hensel et al., 2012). Compared to past crises, the current pandemic is more likely to lead to permanent behavioral changes as it has established entirely new patterns of life—the severity, global scope and long duration of the pandemic have ensured that these patterns have had time to sink in.

Currently, a body of literature is quickly developing on the early-stage behavioral effects of COVID-19, much of which includes projections of post-pandemic behavior. This literature is largely clustered around risk perceptions and preventive responses (Bowman et al., 2020; Hoenig & Wenz, 2020; Qian et al., 2020), travel behavior, work-from-home trends, and consumption behavior. Studies of travel behavior have shown that overall travel has declined dramatically, and travel mode preferences have changed (Abdullah et al., 2020; Brinkman & Mangum, 2020; Brough, 2020; Neuburger & Egger, 2020; Parady et al., 2020). Various studies of work-from-home (WFH) trends have found a third to half of the workforce in European countries and the U.S. working from home as a result of COVID-19 (Bick, Blandin & Mertens, 2020; Eurofound, 2020; Brynjolsson et al., 2020; Morgan Stanley, 2020). Some have suggested that both employers and employees are willing to continue doing so after the pandemic (Bartik et al., 2020; Dubey & Tripathi, 2020; Salon et al., 2021; Mohammadi et al., 2023). Scholars have also highlighted the impact of COVID-19 on consumption trends, with rising trends in online shopping and decreased consumption of non-essential goods; most predict that the rise in online shopping will persist, while others suggest that thrifty spending practices and valuing of space and cleanliness in stores may persist (Arora et al., 2020; Grashuis et al., 2020; Roggeveen & Sethuraman, 2020; Zwanka & Buff, 2021; van Vuuren, 2023).

Scholars are still documenting the substantial changes to consumption, work and travel behavior stemming from the COVID-19 pandemic. However, as vaccination programs begin to take effect, understanding whether and to what degree these behaviors persist in the long run will be vitally important for policymakers to design appropriate policies to facilitate economic recovery and build a more vibrant post-pandemic Hong Kong. Many studies have attempted to understand behavioral persistence using self-reported predictions of post-pandemic behavior, while a growing number have begun to look into more specific factors involved in behavioral changes in order to understand their potential persistence (Irawan et al., 2021; Ozbilen et al., 2021; Inoue & Todo, 2023). These studies suggest that many COVID-19-induced behaviors are likely to persist in the post-pandemic world. With the pandemic continuing to rage unabated in many parts of the world, few studies have been able to collect empirical data on post-pandemic behavior. As COVID-19 gradually comes under control in Hong Kong, it will be important for policymakers to collect empirical data on post-pandemic behavior as early as possible. Moreover, Hong Kong, as a typical high-density metropolis, may experience a different type of behavioral change than what is observed in the United States or Europe.

The dramatic behavioral changes prompted by the pandemic have raised questions about their longevity and persistence as new post-pandemic norms. Findings from the

US (Salon et al., 2021; Salon et al., 2022) suggest that some of these changes, e.g. the increase in telecommuting, online shopping, biking and walking, are likely persist. However, the patterns of pandemic-induced behavioral change may vary considerably from region to region. Hong Kong, as a typical high-density metropolis, may experience different behavioral changes than those observed in the broader US.

Notwithstanding the breadth of research conducted in the context of Hong Kong's response to the COVID-19 pandemic, there remains a significant research gap regarding the enduring effects of the pandemic on the daily behaviors, values, and mental health within this densely populated urban environment. While extant studies have predominantly concentrated on areas such as vaccination intentions (Shah et al., 2022), vaccine hesitancy (Xiao et al., 2022), the efficacy of public health interventions (Zhu et al., 2023), and the ramifications for the tourism sector (Liu et al., 2023), including recovery projections (Zhang et al., 2021), and societal attitudes towards large-scale testing initiatives (Xin et al., 2022), as well as the correlation between unemployment and suicide rates (Men et al., 2022), there is a dearth of empirical research addressing the pandemic's impact on the everyday life of Hong Kong's inhabitants and the extent to which these alterations will persist post-pandemic.

The study by Du et al. (2023) provides insights into the collective behaviors of Hong Kong citizens during the initial outbreak of COVID-19. Nonetheless, their research primarily evaluates the interplay of individuals' emotions, perceptions, and online behaviors in the year 2020, rather than focusing on the continuity of daily behavioral patterns. Similarly, Lee & De Vos (2023) proffer a comprehensive analysis of the motivations and determinants that influenced the adoption of remote work during various stages of the pandemic; however, their study stops short of exploring the potential permanence of work-from-home practices in Hong Kong's future work culture. Delina et al. (2023) examine the impact of the pandemic on sustainable development behaviors within Hong Kong, noting an increased focus on personal hygiene, a shift towards more health-conscious habits, a decrease in the consumption of non-essential goods, and a heightened appreciation for local natural environments. Yet, their research does not extend to a broader evaluation of the persistent nature of these behavioral shifts.

To fill this significant research gap, and track behavioral changes in Hong Kong during and immediately after the pandemic and measure the extent to which behaviors return to (pre-pandemic) normal, we conducted a demographically representative online survey using a sample of addresses drawn from the Hong Kong Statistics Department's hostel framework and collected responses from 3,752 households, with one member from each household asked to complete the questionnaire post-pandemic. The dataset was demographically weighted by the districts to represent the overall profile of Hong Kong residents. These surveys not only cover daily behaviors examined in previous studies, such as telecommuting, consumption patterns, online shopping, and mode of travel, but also take residents’ changes in values and psychological health into count.

1.2 Literature Review

The body of literature on the behavioral impacts of COVID-19 is growing quickly. A large number of studies exist on travel behavior, consumption behavior and work-from-home, whereas relatively fewer studies have been conducted on housing choice, which involves more substantial changes that are slower to manifest. The literature, in general, attests to massive changes in everyday behavior, and many predict significant persistence of behavioral changes in the post-pandemic era, ranging from work-from-home practices to healthier consumption (Arora et al., 2020; Bloom, 2020). Due to the need for rapid data collection, a large number of studies rely on quick or readily available data sources such as online surveys (Shamshiripour, 2020) or mobile phone data to study behavior (Brough et al., 2020; Hara & Yamaguchi, 2021; Chan et al., 2021). Population representative surveys are thus far less common.

Travel, being one of the everyday behaviors most pervasively and directly affected by the pandemic, is a popular topic of investigation. Numerous studies have shown an overall decrease in mobility due to the pandemic, a shift in travel mode preferences from public to private transport, and greater use of non-motorized transport (Abdullah et al., 2020; Brinkman & Mangum, 2020; Brough, 2020; Neuburger & Egger, 2020; Parady et al., 2020; Politis et al., 2021; Salon et al., 2021; Salon et al., 2022; Airak et al., 2023; S. Lee et al., 2023). This decline was much less prominent among individuals with lower levels of education and lower incomes, likely reflecting a lower ability to work-from-home for low-income individuals (Brough, 2020; Irawan et al., 2021; Politis et al., 2021). Meanwhile, some scholars have found that a decline in mobility was more prominent among women—very likely a reflection of women's uptake of family care-taking roles as well as a higher rate of job loss during the pandemic (Politis et al., 2021). Early studies have also suggested that patterns of change in mobility may be significantly different for low-income countries. For example, Anwari et al. (2021) found that increased online shopping, working, and education have mostly been an urban phenomenon in India and pointed out that the continued need for transportation for the rural population is a dire problem. They found that buses, as unsafe as they may be during a pandemic, remain the dominant mode of transportation for both long- and short-distance travel in India.

In Hong Kong in particular, scholars analyzing MTR card data from early in the pandemic found dramatic drops in MTR travel to shopping areas, amusement areas and borders, by 42%, 81% and 99%, respectively (Zhang et al., 2021). Meanwhile, Chan et al. (2021) used direction request and location history data from several different map services (e.g., Google) to detect changes in mobility and found that Hong Kong residents began to consciously restrict their mobility even before the imposition of government social distancing restrictions. Our study adds to this early literature by providing population-representative survey-based data and analysis that can illuminate more dimensions of travel-related behavior.

Changes in consumption patterns have also been a popular subject of investigation during this pandemic. A global survey by McKinsey and Company between May and June of 2020 provides a glimpse of certain emerging trends (Arora et al., 2020). In addition to a general pattern of growth in online shopping, the survey found a shift towards greater emphasis on value and on the essentials in consumption patterns, pointing to a "homebody economy" with significant concerns about out-of-home services, such as restaurants, nail salons, and gyms. They also found a shift toward more careful buying and greater attention to health and hygiene. More broadly, McKinsey and Company found that the pandemic jolted consumers out of normal patterns of consumption, spurring them to try new businesses and new brands. Other studies have corroborated large shifts in consumption patterns and a trend toward greater thriftiness (Arora et al., 2020; Grashuis et al., 2020; Orindaru et al., 2021; Roggeveen & Sethuraman, 2020; Zwanka & Buff, 2021). A few have also highlighted interest in healthier and more locally sourced diets, with implications for sustainability (Hesham et al., 2021; Orindaru et al., 2021). Wang et al.'s (2021) Hong Kong-based study similarly found that dining habits in Hong Kong had shifted towards an increase in home cooking and take-out, and the consumption of more fruits and vegetables, although fast food consumption was not found to have decreased. Chen et al. (2021) documented a sharp decline in consumption in the first 12 weeks of the pandemic in Hong Kong, with a significant reduction in dining. Data thus far suggest dramatic changes in consumption patterns, some of which, such as interest in more healthy foods and habits of online shopping, may persist beyond the pandemic. However, a recent study from Japan (Inoue & Todo, 2023) points out that the popularity of online shopping is not sustainable, and therefore our research is needed to further validate this behavioral trend.

Working practices, including remote work and remote conferencing, are also a widely documented and discussed result of the pandemic. Studies during the first few months of the global pandemic found rates from 30% to 50% of the workforce working from home in Western countries, and work-from-home (WFH) trends increased dramatically even in less developed countries. Scholars agree that WFH is likely to persist at rates much higher than before the pandemic (Bick, Blandin & Mertens, 2020; Eurofound, 2020; Brynjolsson et al., 2020; Morgan Stanley, 2020; Salon et al., 2021; Mohammadi et al., 2023). The technological investment by companies and individuals to make WFH possible has been catalyzed by the pandemic, while resistance to the practice may have largely been altered by a long period of use and growing familiarity with WFH technology and management methods. The fully established infrastructure means the balance has likely been tipped much more strongly in favor of WFH in the post-pandemic era. As the pandemic stabilizes in some areas, interesting debates and phenomena are already beginning to emerge in WFH patterns. While on the one hand, tech companies such as Facebook and Microsoft have announced the intention to dramatically increase WFH for the long run early in the pandemic, new debates have emerged as the pandemic is coming under control. Most recently, Facebook announced

plans in May 2021 that specified only the most senior and experienced employees are to work remotely, while others are required to engage in a hybrid office and remote work format. Under pressure from employees, Facebook then announced plans in mid-June to allow all full-time employees to request permanent remote work if the nature of work allows. Facebook also announced plans to begin allowing employees to request remote work across international borders (Rodriguez, 2021). While the IT sector allows for some of the most extreme possibilities for remote work, it is likely that many white-collar occupations could follow suit in the future, whether for day-to-day work or conferences that would have required travel in the past. However, studies on remote work in Hong Kong remain scarce, even though WFH has been widely practiced for some time during the pandemic. Our study therefore contributes to the understanding of how widespread and persistent WFH is and will be after the pandemic.

Housing choices, finally, have also been clearly impacted by the pandemic in certain regions of the world. Scholars began discussing the potential for dramatic changes in housing patterns very early on in the pandemic, with Nicholas Bloom (2020) and Ahmad Gamal (2023) discussing the potential of a population shift towards suburban areas away from the urban cores and towards low-rises over dense high-rise buildings. In the U.S., the media has repeatedly highlighted this phenomenon, pointing to an exodus from large cities to more peripheral locations advertising themselves as havens. However, some reports also claimed that the exodus was concentrated in America's largest cities, such as San Francisco and New York, while the migration has primarily been toward smaller cities rather than to small towns or rural areas (Patino, 2020). Using home sales data, a study by Liu and Su (2020) found that housing demand in the U.S. indeed decreased in higher-density neighborhoods and neighborhoods with higher pre-COVID housing prices. Research from Beijing (Zhao & Gao, 2023) also suggests that the pandemic encouraged the suburbanization of relatively older, higher-income household migrants, and that the pandemic accelerated the decentralization of the spatial distribution of employment, which may have contributed to further breaking down the monocentric urban structure. With many of the amenities of city life off limits due to the pandemic, as well as the increased ability to telework, formerly attractive areas in cities may become much less so. In Hong Kong, the average resident is under strong housing pressure and lives in a relatively small space. For reasons similar to those suggested by Liu and Su, Hong Kong residents may have developed different housing preferences over the course of the pandemic, such as a preference for less crowded areas in the New Territories. Thus, we also investigate housing choice due to evidence of a global shift and its particular relevance to Hong Kong. However, there are too few responses in our sample that relate to changes in housing behavior for us to be able to give a sufficiently convincing picture of housing behavioral change.

1.3 Policy Relevance

The study provides timely empirical data and analysis to help policymakers differentiate temporary and permanent behavioral changes induced by the pandemic. Whether behavioral changes such as working from home and online shopping persist will have major implications for public policy. Understanding the changes in catering and travel behavior could help the government to design more concrete housing and transportation plans and policies for better implementation of the *Lantau Tomorrow Vision* and *Northern Metropolis Development Strategy*. The Hong Kong Chief Executive's Policy Addresses in recent years have consistently emphasized the importance of new public housing development, much of which will be in new town areas. Since the de-industrialization of Hong Kong, jobs have been concentrated in the downtown core, and many developing new towns are characterized by a lack of jobs nearby. If there is indeed a shift in WFH an thus demonstrates preferences towards less dense housing due to the pandemic, policymakers could use the opportunity to attract wealthier residents to underdeveloped new towns via building high-end private housing, integrating it with well-designed public housing, and develop programs to support start-ups and job creation in those areas. Actively encouraging such shifts in residential patterns, in alignment with new preferences, could encourage better job-housing balance, more social mixing, and more economic opportunities for people living in these public housing communities.

Furthermore, understanding behavioral shifts can help policymakers determine what types of economic support policies are appropriate to foster economic recovery. Since the beginning of the pandemic, the government has offered various economic support programs to help businesses and their employees weather the crisis, from one-off subsidies like the Retail Sector Subsidy Scheme to rental concessions and loan payment deferrals. However, if behaviors like online shopping persist, there may be reduced prospects for certain offline retail sectors to recover and government support should be phased out accordingly. Instead, resources might be applied to employees' job re-training or towards support for the development of new industries.

Lastly, COVID-19-induced travel behavior changes could also have tremendous long-term impacts on Hong Kong's environmental sustainability. To reduce congestion caused by the rise of private vehicle use during the pandemic, the government announced the increase of private vehicle registration taxes and annual licensing fees in February 2021. Understanding whether preference for private vehicles is "sticky" can help policymakers determine whether further measures to control private vehicle use will be necessary, or whether we can expect a resumption of public transportation use without further intervention.

II. OBJECTIVES OF THE STUDY

1. Conduct surveys and collect empirical data to understand the extent to which different COVID-affected behaviors return to pre-pandemic patterns within the one-year and half time period of this study.

2. Investigate the reasons behind COVID-19-induced behavioral changes during and immediately after the pandemic. That is, in addition to the direct impact of COVID-19 on behavior, how do various intervening variables mediate the behavioral impacts of COVID-19? Specifically, we will empirically examine the following intervening factors:

a. How do changes in economic circumstances mediate COVID-19's effects on behavior?
b. How do changes in access to technology mediate COVID-19's effects on behavior?
c. How do changes in attitudes and values mediate COVID-19's effects on behavior?
d. How do changes in stress mediate COVID-19's effects on behavior?

3. Based on patterns of behavioral changes during and immediately after the pandemic and analysis of the intervening variables involved in these changes, we will then use our model to predict the extent to which different COVID-19-induced behavioral changes are likely to persist into the future.

4. Explore how behavioral persistence differs for different segments of the population.

III. RESEARCH METHODOLOGY

3.1 Theoretical Framework

In addition to collecting empirical data on the degree and pace of behaviors "returning to normal" as the pandemic recedes, this study attempts to understand the intervening factors determining behavioral changes. Given the short time frame of the study, the extent to which predictions can be made on the basis of purely descriptive data may be limited. A deeper understanding of the causal factors involved can help us to better predict which behaviors will last. On the one hand, the objective health risks of the pandemic and economic downturn have led to a wide array of behavioral changes. On the other hand, in addition to directly affecting behavior, COVID-19 risk and economic challenges have affected various intervening variables that may also have an impact on social and economic behaviors (Figure 1). By examining how these intervening variables mediate the effects of COVID-19 and economic recession on behavioral changes, we are able to form stronger predictions on which behaviors may persist into the future. Note that in the proposal of this study, the economic condition is treated as an intermediate factor for COVID-19. Yet during the study, we come to realize that a worsening economic condition, though a disastrous consequence triggered by the COVID-19 pandemic, is itself evolving in an unpredictable way, and hence exogenous to this behavior model. Moreover, considering the regionality of this study, it's reasonable to assume that COVID-19 health risks (measured as number of confirmed cases near residential location) and their consequences are not totally localized. That is to say, the economic impacts of an outburst of COVID-19 cases in a region of Hong Kong could easily spill over to the whole city, and influence most of the society. Therefore, the modified theoretical model treats both COVID-19 health risks and economic situation as two exogenous variables.

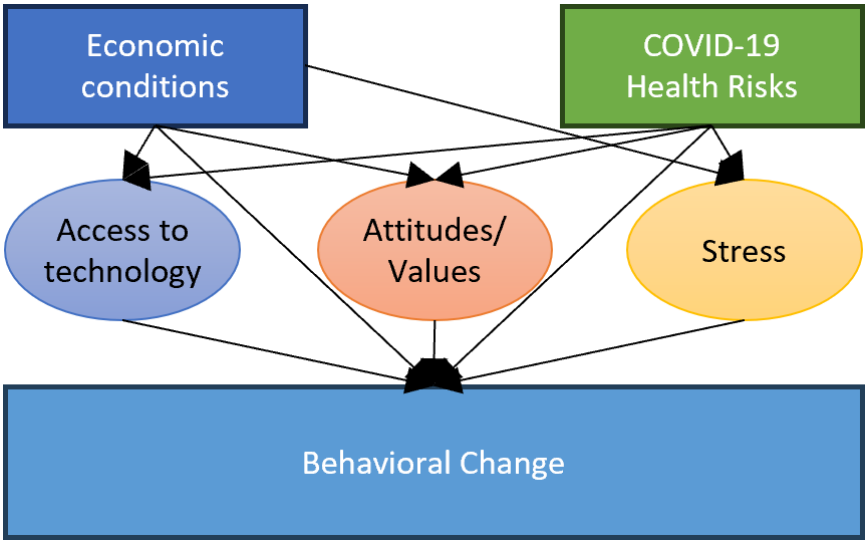


Figure 1. How COVID-19 and economic challenges may lead to behavioral changes—direct and mediating effects.

We can infer that behavioral changes stemming from direct COVID-19 risks, limping economic situations, and different intervening variables have different likelihoods of persisting after the pandemic. First, behavioral changes stemming directly from COVID risks are likely to fade away in the normalization period. After excluding mediation effects of stress and attitudes/values, the direct influence of covid risks on behavior changes might be due to movement-restricting policies. With the lift of restrictions after the pandemic, such changes could be undone.

Those stemming primarily from changes in economic circumstances are likely to last as long as the COVID-19-induced economic recession does, but are likely to return to normal with an economic recovery. Those stemming primarily from changes in access to technology are likely to persist in the long run, along with the long-term trend of technological improvement. Those that stem from attitude and value changes are less predictable, but are likely to be somewhat "sticky", and could persist in the long term. Finally, those stemming primarily from stress are likely to be short-term, fading away as stress induced by the pandemic subsides.

A tightened **financial situation** directly affects consumption behavior, ranging from types of clothing to types of food (Shim & Cho, 2000; Griffith et al., 2016). Scholars have documented the cutting of non-essential consumption during the current pandemic, which to a certain extent may be due to restricted activity, but another part of which is undoubtedly due to constrained financial circumstances (Arora et al., 2020; Grashuis et al., 2020; Roggeveen & Sethuraman, 2020). As long as a depressed financial situation persists after the pandemic, so will the associated consumption behavior, but the financial recovery could lead to behavior returning to pre-pandemic patterns. Indeed, the speed of economic recovery in some countries where the pandemic is subsiding, including China and the US, has surprised many observers. With the rapid re-emergence of new businesses and job opportunities, behavioral changes associated with depressed *economic circumstances* may already be in reversal (Hale et al., 2021; Guilford & Cambon, 2021).

Based on the literature, we have identified three intervening variables that are likely to be involved in behavioral changes seen during the pandemic: **access to technology**, **attitudes and values**, and **stress**.

Changes in **access to technology**, both in terms of the quantity and quality of technology an individual has access to, as well as in familiarity with technology, are likely to be permanent. This implies that behavioral changes where technology is a prominent intervening variable are also likely to persist. The literature on remote work, including PI's own research in the past decade, suggests that telecommuting and WFH had been on the rise even before the pandemic as technologies that facilitated such activities being developed (Zhu, 2012, 2013; Zhu et al., 2018; Zhu, working paper). The pandemic has further accelerated the development of technology in these areas, forcing people and corporations to invest in infrastructure and technology that enable essential activities to take place online, and to invest the time and effort necessary to

learn to use the technology. The ability to monitor employees' work and ensure productivity was one of the main concerns associated with WFH, but the pandemic accelerated the adoption of technological tools to address this problem (Hart-Landsberg, 2020; Satariano, 2020). Investments in equipment such as better cameras for conference calling and better internet connections further increase the long-term incentives to work from home. The infrastructure and skills acquired by employees and companies for remote work, online shopping and other online activities are unlikely to disappear after the pandemic. While some of the restrictions on in-person activities will be lifted, the improvement to the underlying technological infrastructure facilitating online and remote activities will likely enable these behaviors to stay at higher than pre-pandemic levels after the pandemic.

In addition to economic recession and technological advancement, which have been widely pointed out as important side-effects of the pandemic, we draw on Andreasen's (1984) theory of the effect of life events on consumer behavior to identify other potential intervening variables in pandemic-related behavioral changes. Andreasen theorizes how major life events such as switching jobs or having children may not only have direct effects on consumer behavior, but may also induce changes in intervening variables, such as lifestyle and stress, thus indirectly affecting consumer behavior. Andreasen defines lifestyle changes as changes triggered but not necessitated by a major life event, with the event acting as an opportunity to rethink one's lifestyle, for example prompting one to be more concerned about health, or to adopt a new hobby. We draw on Andreasen's study, but understand such lifestyle changes (which Andreasen also refers to as changes in interests and priorities) as reflections of changes in underlying attitudes and values. Thus, we use changes in *attitudes and values* as our third intervening variable.

The pandemic is likely to lead to significant changes in **attitudes and values** that will have important implications for social and economic behaviors. Such changes may persist well beyond the pandemic. Many scholars have discussed the effect of cataclysmic events on attitude and value changes, both in the context of COVID-19 and other events. Some have surmised that COVID-19 will make space, cleanliness and health long-term priorities (Bloom, 2020; Roggeveen & Sethuraman, 2020). Dombey (2004) argued that such a value change occurred as a result of the 2003 SARS crisis. Others have discussed the possibility of COVID-19 leading to either an increase in stocking-up behaviors, due to a newfound awareness of the possibility of crisis, or greater hedonism and the desire to enjoy life as much as possible (Zwanka & Buff, 2021). Etzioni (2011) pointed out that the 2008 sub-prime mortgage crisis and subsequent Great Recession led to concerns that society had become too shallow. Meanwhile, the crisis also led to the admiration of people who live simply and an emphasis on saving. He predicted that such changes in value would have a lasting impact on American consumer behavior, even after financial circumstances returned to normal. Debevec et al. (2013) also noted the lasting impact of the Great Recession on the generation that came of age specifically during this time period, but found that instead of leading to decreased consumerism, the experience of the crisis led to less

thriftiness and an attitude of enjoying life to the fullest. Kennett-Hensel et al. (2012) found that survivors of Hurricane Katrina generally purchased fewer and cheaper things, even after their incomes had returned to normal, due to an awareness of the potential for sudden loss of material possessions. Shi and Cho (2010) found that the Asian financial crisis led to greater value being placed on functional styles of clothing and local brands among Korean consumers, but that these value changes also varied by income level. Like these previous crises, COVID-19 may lead to deep changes in attitudes and values that could last well beyond the pandemic itself. Therefore, behavioral changes linked to such value shifts are also likely to be "sticky" and persist independently of changes in material circumstances after the pandemic.

Finally, scholars have suggested that during catastrophic events, another mediating factor influencing behavior is **stress**. Andreasen (1984) found that stress leads to a greater sense of dissatisfaction and therefore also contributes to changes in consumer behavior after major life events. Other scholars have corroborated this view (Kennett-Hensel et al., 2012). However, stress effects are expected to be short-term and should wear off with the end of the crisis or possibly even earlier as people adjust to new circumstances. In the immediate aftermath of Hurricane Katrina, while most survivors became thriftier, a significant number of victims became inclined to purchase luxury items as a way of seeking emotional comfort in the face of stress and uncertainty. However, such an effect was seen mostly in the immediate aftermath of the disaster and eventually wore off (Kennett-Hensel et al., 2012). Therefore, behavioral changes associated primarily with stress are likely to return to pre-pandemic states as the pandemic recedes.

As illustrated in Figure 1, our theoretical framework also takes into account the interactions among all intervening factors. By examining how behavioral changes are mediated by these different factors, we are able to better predict which behaviors will persist in the long term, and which are likely to wear off. Behavioral changes driven primarily by stress are very different than those driven by fundamental value changes. If, for example, higher levels of stress are associated with higher levels of cooking at home, perhaps because cooking represents a form of stress relief, our perceptions of the trend toward home cooking could be inflated. If, however, cooking at home is associated with changed values in favoring thrift and health, a longer-term trend would be implied. Using our theoretical framework and timely empirical data on behavioral changes collected as the pandemic comes to a close, we are able to provide insight into which behavioral changes can be expected to become part of our new normal in the post-pandemic world.

3.2 Survey Design

Our research is based on questionnaires conducted using the survey infrastructure of the Hong Kong Panel Study of Social Dynamics (HKPSSD). Initiated by the Center for Applied Social and Economic Research (CASER), where the PI is the Associate Director, the HKPSSD was the first population-representative household panel study in

Hong Kong. The HKPSSD applies a stratified replicated sampling design, with a random sample of addresses from the Frame of Quarters of the Hong Kong Census and Statistics Department. HKPSSD data are collected via computer-assisted face-to-face interviews at the household and individual levels for each member of the sampled household. Four waves of the HKPSSD have been carried out since 2011, with each wave collecting data on a representative sample of over 2,000 Hong Kong households. The first wave, conducted in 2011, successfully surveyed 3,217 households (7,218 adults and 958 children). Three subsequent waves were conducted in 2013, 2015, and 2017, each of which collected surveys from over 2,000 households. Two refreshment samples were added in 2014 and 2019 to replace units lost due to panel attrition, with 1,007 new households (1,960 adults and 145 children) added in 2014 and 840 new households (1,102 adults and 119 children) added in 2019.

Leveraging the infrastructure of the HKPSSD, we first conducted a demographically representative online survey using a sample of 34,000 addresses drawn from the Hong Kong Statistics Department's hostel framework and collected responses from 3,752 households, with one member from each household asked to complete the questionnaire post-pandemic. A further round of supplementary surveys was conducted in the summer of 2023, to which 273 responses were received. The dataset was demographically weighted by the districts to represent the overall profile of Hong Kong residents. Respondents are offered HK$50 each for completing the questionnaire as a survey incentive.

HKPSSD data include key modules on household situation, demographics, education, immigration, employment and self-employment, health and medical care, and subjective well-being, encompassing data on all basic variables necessary for our analysis. The new survey questionnaire for this study mainly focusses on respondents' various behaviors and those intervening factors, while also collecting updated information on respondents' basic socioeconomic conditions, including employment and education. We include retrospective questions about behavior before and during the pandemic as well as questions about current behavior at the time of the survey.

Specifically, our behavioral questions cover work (including telecommuting and working from home), travel (including transportation mode choice and car ownership), shopping (including online shopping and food delivery), and housing (including homeownership, housing type, housing expense and location choice). As discussed earlier, an important and innovative part of this research is that we incorporate four key mediating or intervening factors into our theoretical framework. Our questionnaire also covers these factors and specifically asks about changes in the respondents' economic circumstances, access to technology, attitudes and values, and stress before, during and after the pandemic.

3.3 Data Analysis Methodology

This study employs the structural equation modeling (SEM) approach to analyze factors contributing to changes in traveling behavior. The basic structure of the empirical specification can be summarized using the following equations. Equations 1 and 2 regress the dependent variable on a set of independent variables, for the T1 and T4 periods, respectively. In specific, in Equation 2, the independent variables X_{T_4} are decomposed into two components, X_{T4-T1}representing the shift from T1 to T4 and X_{T1} representing the T1 initial value. Then, we subtract Equation 1 from Equation 2, as shown in Equation 3. Equation 4 is the equation to be estimated by the SEM model, where the dependent variable is the travel behavioral changes measured between T4 and T1, and the independent variables are included not only in delta form but also presented by the initial T1 values.

$$Y_{T1} = \beta_0 + X_{T1}\beta_{T1} + \epsilon_{T1} \dots (1)$$

$$Y_{T4} = \gamma_0 + (\Delta X_{T4-T1} + X_{T1})\gamma_{T1} + \epsilon_{T4} \dots (2)$$

$$Y_{T4} - Y_{T1} = \gamma_0 - \beta_0 + \Delta X_{T4-T1}\gamma_1 + X_{T_1}(\gamma_1 - \beta_{T1}) + \epsilon_{T4} - \epsilon_{T1} \dots (3)$$

$$\Delta Y_{T4-T1} = \alpha_0 + \Delta X_{T_{4-1}}\alpha_{T_{4-1}} + X_{T_1}\alpha_{T_1} + \zeta_i \dots (4)$$

There are four groups of dependent variables of interest. The first group of dependent variables is the daily travel behavior, measured by four output variables, including driving alone frequency, carpooling frequency, ride-hailing or taxi usage frequency, and public transit usage frequency. The survey questions ask respondents about the frequency of each travel mode in a week. Using carpooling frequency as an example, the question is framed as: "On average, how many days per week did you drive or ride in a private vehicle with at least one other person in the car". There are four options: Rarely/ Never, 2=Occasionally (1-2 days), 3=Sometimes (3-4 days), and 4=Always/usually (5+ days). The categorical variables are then mapped into continuous variables, which measure the percentages of days using a particular kind of transportation mode in a week.

The second group of travel behaviours of interest is the choice of commuting mode. The commuting analysis focuses on four output variables measured in use percentage: private vehicles, public transits, ride-hailing/taxi, and working from home. The variables are generated based on one survey question respondents to indicate the percentage of different commuting modes: "What were your primary means of commuting to school or work? (Please indicate the percentage of commute trips you make using each of the following modes: working from home, using a private vehicle, using a taxi or ride-hailing, using public transport, biking, walking, and others)". The seven indicated percentages would add up to 1. Since the focus of this study is on the persistence of travel behavior change, the output variables should reflect the difference between T4 (Jun-Sep 2022) and T1 (second half of 2019). Therefore, output variables

are constructed by subtracting the T1 mode frequency from its T4 counterpart, ranging from -1 to 1. A higher value suggests a greater increase in each mode usage.

The third group of dependent variables is the catering behavior, including frequency of dining at a restaurant, frequency of food pick up at a restaurant, and frequency of food delivery. Take dining in as an example, the corresponding survey question is "On average, how many days per week did you order food for pick up at a restaurant", with options: Rarely/ Never, 2=Occasionally (1-2 days), 3=Sometimes (3-4 days), and 4=Always/usually (5+ days). The categorical variables are then mapped into continuous variables, which measure the percentages of days having a specific type of catering behavior in a week.

The last group of dependent variables is consumption behaviors, including frequency of physical grocery shopping, frequency of online grocery shopping and frequency of online shopping (excluding groceries). The survey questions for these three variables are framed in a similar manner as the ones for daily travel mode choice and catering behavior, asking the respondents about the number of days per week when they have a specific type of shopping behavior. The options are also the same, hence the three consumption variables have the same data structure as the one for daily travel mode choice and catering behavior.

Figure 2a visualizes the SEM framework for the study. The SEM model considers the influence of sociodemographic characteristics, economic circumstances, COVID risk, behavioral changes happening during the pandemic (labeled with Δ), and behavior before the pandemic (labeled with T1). The figure uses rectangles with dashed borders to indicate the grouping of the variables and to reduce the number of arrows between nodes for the sake of tidiness and simplicity of the plots.

In the third column from the left, ΔY_1, Δy_2 to ΔY_n represent the dependent variables. For each behavior topic (i.e., daily travel mode choices, commuting mode choices, catering and consumption), all the dependent variables enter the model simultaneously, which will take into account the covariance between the dependent variables. For instance, in the SEM model for daily travel, there are four dependent variables, namely driving alone frequency growth, carpooling frequency growth, taxi/ride-hailing frequency growth, and public transit usage frequency growth, whose covariance will be captured by the model. Similarly, there are three dependent variables each for the commuting mode choice model, catering behavior model and consumption model.

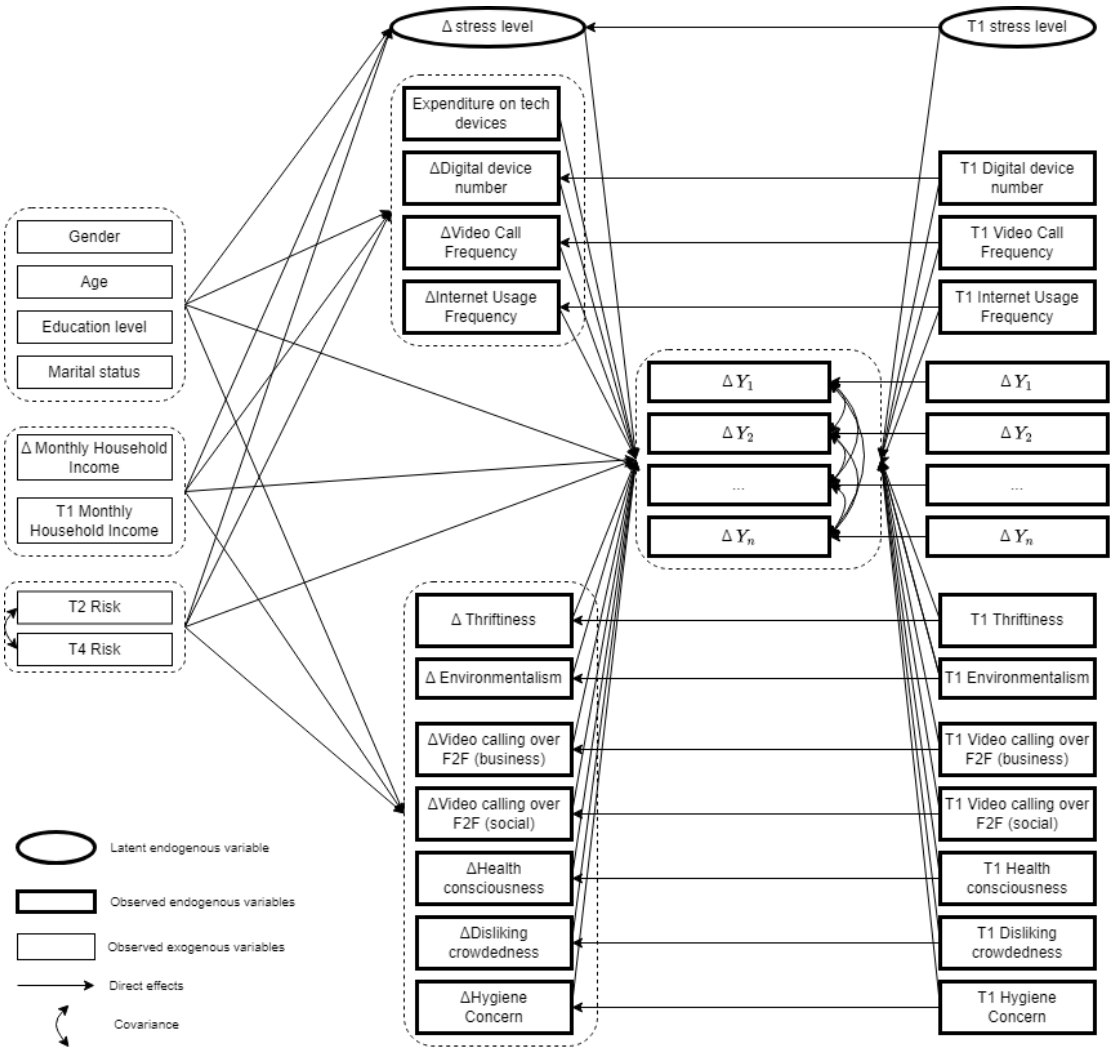


Figure 2a. SEM of COVID-19's impact on behavior.

The first column from the left presents the exogenous variables of the model, including COVID risks, economic situation and socio-demographic attributes. **Sociodemographic attributes** are measured by gender, age, education levels and marital status, which take T4 values.

Economic circumstances are treated as observed exogenous variables. It is directly measured by monthly household income. Standard questions in the HKPSSD on employment situation and income are adjusted to collect both retrospective and current data on the respondent's economic situation. Average monthly household income in 2019 was used to represent pre-pandemic income, while average monthly household income in 2020 was used to represent the economic situation during the pandemic. The SEM models include both the monthly household income at T1 and also the changes in household income from T1 to T4, labeled as T1 Monthly Household Income and Δ Monthly Household Income in Figure 2a.

The **COVID risk index** quantifies the proximity of COVID-19 infection cases to the

residential location, serving as an objective risk measure. While the pandemic has imposed a threat on society generally, geographic differences in COVID risk exist. Two residential risk indices are included in the model to capture the spatial variation of COVID risk and investigate how it impacts people's behavior. This index is derived from publicly available information about residential and non-residential buildings associated with COVID-19 cases. The Hong Kong Government's daily reports from January 23, 2020, to December 29, 2022, provided building names and report dates for each case. We obtain the geographic coordinates of listed buildings via Google Map API. The dataset is divided into three periods according to report dates corresponding to the survey's structure: Feb-Apr 2020 for T2, Feb-Apr 2022 for T3, and Jun-Sep 2022 for T4. Within each period, records are aggregated at the Tertiary Planning Units & Subunits (TPUSB) level. The resulting risk index quantifies the total number of reported cases in each TPUSB during each period. A regression analysis of driving alone frequency to test for multicollinearity among all the independent variables, including a risk index for T3, indicates that all variables have a VIF value lower than 2.1, except that the T3 and T4 risk indexes have a high VIF value of 5. The VIF value decreases to be smaller than 2 if any one of the two variables is dropped from the model. Hence, to investigate the impacts of the latest risk on behavior changes, we preserve the T4 risk index and exclude the T3 index. In Figure 2a, they are labeled "T2 Risk" and "T4 risk".

The second column from the left of the framework includes intervening variables. We focus on the following three types of intervening variables: psychological stress level, access to technology, and attitudes/values.

Stress is a latent endogenous variable that is constructed from six standard indicators used in previous waves of the HKPSSD, namely "feeling scared without reason in the past week," "feeling nervous or panicky," "feeling heart activity (e.g., heart rate increase, heart missing a beat)," "having difficulty breathing," and "suffering from insomnia". These questions are selected and modified from the standard questions on the self-reported DASS-21 (Scholten et al., 2017). Respondents choose from 0 to 3 for each indicator, where a higher value suggests a higher level of severity. Cronbach's alpha statistics (ranging between 0 and 1 with higher values indicating better reliability) are calculated for T1 and T4 latent stress levels, respectively, to test for the reliability of the six construct indicators in each period. The results show that T1 indicators have an alpha value of 0.834 and the ones in T4 have an alpha value of 0.864, which suggests that the indicators in each period have good internal consistency (Cortina, 1993).

The models include both the difference between T4 and T1, and the T1 initial value, to investigate the impacts of stress changes in the intervening variables while controlling for the influence of initial values. The change in the latent stress level is constructed from a latent change score model (LCSM) modified from the framework by Kievit et al. (2018). Figure 2b illustrates the details of the LCSM. The model decomposes the T4 latent stress variable into two components: the T1 latent stress variable, and the latent

change score for stress level between T1 and T4. The model allows for autoregression by estimating the β, the regression coefficient of $T1\,Stress$ on $\Delta\,Stress$. The covariances between each stress indicator across T1 and T4 are also captured in the LCSM. The LCSM estimates the three latent variables, and the results of the T4 stress level and latent change of stress score enter the main SEM models. For observed endogenous variables, the difference is calculated from a direct subtraction of T1 values from T4 values. The labels in Figure 2a for stress levels are $\Delta\,stress\,level$ and $T1\,stresss\,level$.

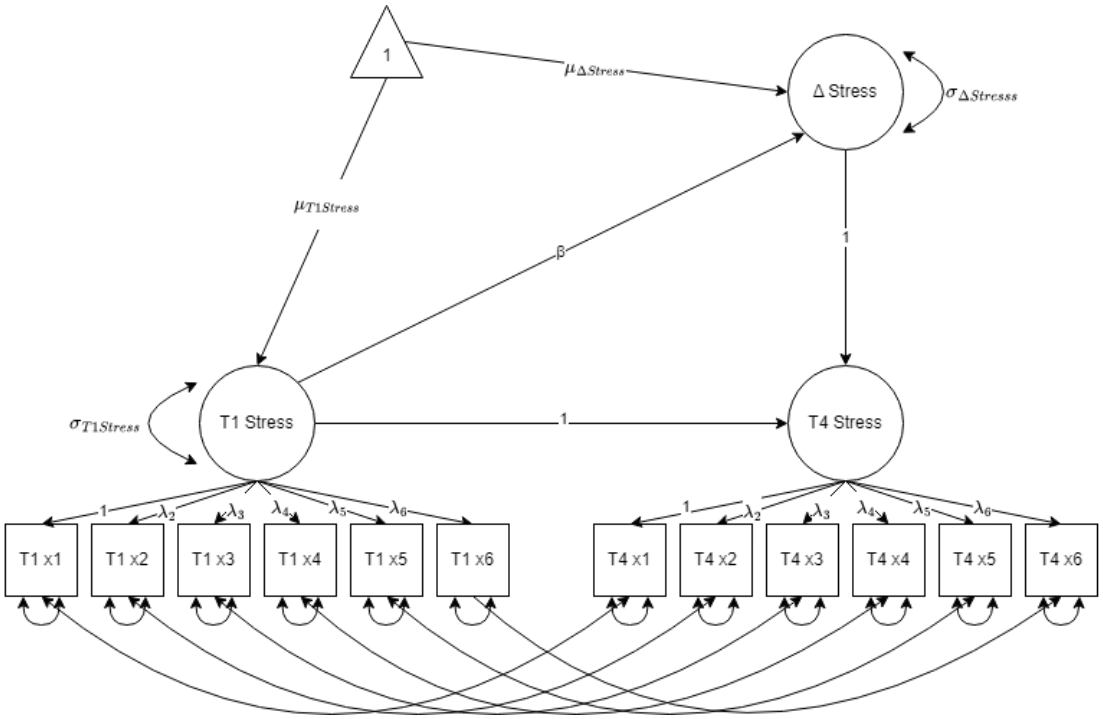


Figure 2b. Latent change score model for stress level

Access to technology is represented by four observed endogenous variables, i) the range of hardware and software the respondent has access to, ii) the cumulative monetary value of the hardware/software s/he has access to, and iii) her/his technology familiarity. The number of digital devices counts the total number of devices the respondent possesses, including smartphones or tablets, and computers (laptop/desktop). Expenditure on digital devices measures the household spending on new technology products since the pandemic, including hardware like computers, iPads, phones, and office software, not including internet fees or online entertainment services. Familiarity with technology variables contains two observed endogenous variables, including the frequency of browsing the internet on computers and the frequency of video calls/meetings. For each variable, the survey questions ask about the number of days using the technology in a week, with four options: Rarely/ Never, 2=Occasionally (1-2 days), 3=Sometimes (3-4 days), and 4=Always/usually (5+ days). The categorical variables are then mapped into continuous variables, which measure the percentages of

days using a particular kind of technology in a week. Similarly, the model includes both the changes in access to technology and also their individual values (except for expenditure on technology devices). The labels in Figure 2a are $Expenditure\ on\ tech\ devices$, $\Delta Digital\ device\ number$ ($T1\ Digital\ device\ number$ for initial T1 value), $\Delta Videocall\ frequency$ ($T1\ Videocall\ frequency$ for initial T1 value) and $\Delta Internet\ usage\ frequency$ ($T1\ Internet\ usage\ frequency$ for initial T1 value).

The **attitude and value** variables are also composed of a series of observed endogenous variables that enter into the SEM separately. Variables include thriftiness, environmentalism, preferring face-to-face over virtual interaction in cases of business meetings or friend visits, dislike against crowding, hygiene consciousness, and health consciousness, are captured in the model to measure citizens' attitudes/values. In our survey questionnaire, each attitude/value was based on one statement that respondents will rate on a 5-point scale of agreement, such as "I prefer face-to-face interaction to virtual interaction" and "protecting the environment is very important to me." As with the measurement of stress, respondents were asked to rate their current attitude and then asked to rate their attitudes during and before the pandemic. Each variable ranges from -2 to 2, with a higher value indicating a stronger agreement with the statement. In figure 2a, they are represented by the nodes on the lower part of the plot, e.g., $\Delta Thriftiness$ and $T1\ Thriftiness$.

Similar to the case of Figure 2b, the SEM model also allows for autoregression by estimating the impact of T1 values on the level of changes, represented by the arrows pointing from T1 values to their corresponding delta changes. The models for daily transportation, catering and consumption behavior are estimated on the full sample, while the one for commuting mode choices is based on samples that were employed both in T1 and T4 (working sample, hereafter). All continuous variables are standardized to enable comparison of coefficient magnitude.

IV. RESEARCH RESULTS

4.1 Descriptive Results of Behavioral Changes

Statistic summary on sample demographics

Compared to the Hong Kong 2021 Census, the sample for this study is more representative of the working population, whilst ensuring that it is based on the prerequisites of sampling at random. As the questionnaire was completed by only one member of each household, and the QR code on the invitation letter of the questionnaire had to be scanned by mobile phone for completion, this sample inherently has certain specificities compared to the overall population of Hong Kong. In particular: 1) a younger age distribution; 2) a higher level of education; and 3) a higher level of personal income (see Table. 1). The population with the above characteristics is likely to be the most vibrant and mobile population in Hong Kong today. Moreover, the questionnaire was distributed in a demographically weighted manner based on the 18 districts in Hong Kong and is therefore representative of the overall profile of Hong Kong residents. Therefore, based on the above characteristics, this sample is more representative of the daily behavior, mental health, and value changes of the most active part of the population in Hong Kong, which could provide more targeted evidence or implications for relevant policymaking.

Table. 1 Statistic summary of survey sample demographics

Demographic Variable	Proportion (%) in Survey Sample	Relative Proportion (%) in 2021 Census
Gender:		
Female	53.11	54.38
Male	46.89	45.62
Birthplace:		
Hong Kong	75.27	61.7
Mainland China	26.21	29.9
Others	2.12	8.4
Education:		
Primary School or below	2.68	24.5
Lower Secondary	8.84	16.9
Higher Secondary (Including Secondary 5 & Sixth Form)	28.94	25.2
College/ Community College/ Post-Secondary (Non-degree)	14.85	10.5
Bachelor's degree*	30.62	22.9*

Master's degree or above	14.06	N/A
Age:		
19-29	18.30	13.17
30-39	27.03	16.08
40-49	22.05	17.48
50-59	17.60	19.58
60-69	11.32	18.30
70+	5.48	15.38
Income:		
Less than $10,000	6.50	12.54
$10,000-19,999	26.28	37.98
$20,000-29,999	24.60	20.85
$30,000-39,999	15.91	10.14
$40,000-59,999	13.55	9.16
$60,000+	13.15	9.33

**Bachelor's degree: 22.9% represents the proportion of the population with a bachelor's degree or higher in the 2021 Hong Kong Census*

Telecommuting

In this study, only respondents of employment status in each period were asked questions on their telecommuting & online meeting behaviors. Notably, the number of responses is inconsistent because the number of people employed in each phase is different. The results unveil that the prevalence of telecommuting cannot persist in the post-pandemic era, while the rise in online meetings is of strong stickiness.

Table. 2 Summary statistics on telecommuting and online meetings (in proportion)

	Before the pandemic (second half of 2019)	First wave pandemic (Feb-Apr 2020)	Fifth wave pandemic (Feb-Apr 2022)	Normalization (June-Sep 2022)	Difference (T4-T1)
Working From Home *(at least have the option to)*	38.83%	57.36%	61.60%	40.36%	1.53%
Working From Home *at least one day a week*	27.90%	53.50%	56.50%	28.86%	0.96%
Working From Home *at least three days a week*	12.75%	29.90%	37.09%	14.83%	2.08% **
Having Online Meeting *at least one day a week*	27.32%	44.76%	49.66%	39.04%	11.72% ***
Having Online Meeting *at least three days a week*	10.17%	19.32%	25.10%	17.13%	6.95% ***

Although the proportion of Hong Kong residents telecommuting (at least having the option to) during the pandemic increased substantially compared to the pre-pandemic period (as shown in Table. 2), it almost reverted to the same level in the second half of 2019 after the pandemic, with only a 1.53 percent increase, which is not statistically

significant from the t-test. The frequency of "working from home at least one day a week" also suggests a similar conclusion: the prevalence of telecommuting is not persistent. Though the difference between pre-pandemic and normalization of "working from home at least three days a week" is of statistical significance (+2.08%), it is still far from sufficient to suggest that telecommuting will have persistence post-pandemic, for its tremendous plunge from 37.09% amid the fifth pandemic to 14.83%, indicating a convincing trend towards pre-pandemic level.

Further, when examining the variation in telecommuting behavior by gender, as shown in Table. 3, this study finds that Women had a higher tendency toward WFH amid the pandemic. During the pandemic, kids were required to stay at home and take online classes, therefore women, who are usually more likely to be responsible for household chores and childcare (Abromaviciute & Carian, 2022), were more inclined to telecommute. However, the percentages for telecommuting are higher for males post-pandemic, suggesting a stronger stickiness on telecommuting for males. This supports the pre-pandemic study that males are more prone to telecommute (Shabanpour et al., 2018).

Table. 3 Summary statistics on telecommuting & online meetings with gender (in proportion)

	Before the pandemic (second half of 2019)		First wave pandemic (Feb-Apr 2020)		Fifth wave pandemic (Feb-Apr 2022)		Normalization (June-Sep 2022)	
	Female	Male	Female	Male	Female	Male	Female	Male
Working From Home *(at least have the option to)*	38.56%	39.09%	58.09%	> 56.66%	64.16%	> 59.21%	39.96%	< 40.73%
Working From Home *at least one day a week*	27.84%	27.96%	54.43%	> 52.62%	59.94%	> 53.29%	27.47%	< 30.18%
Working From Home *at least three days a week*	13.52%	12.01%	32.46%	> 27.45%	41.06%	> 33.37%	14.41%	< 15.23%
Having Online Meeting *at least one day a week*	25.95%	28.66%	44.61%	44.90%	51.20%	48.21%	38.33%	39.72%
Having Online Meeting *at least three days a week*	9.64%	10.69%	19.65%	19.01%	25%	25.19%	15.76%	18.44%

Table. 4 Summary statistics on telecommuting & online meetings with income (in proportion)

	Before the pandemic (second half of 2019)		First wave pandemic (Feb-Apr 2020)		Fifth wave pandemic (Feb-Apr 2022)		Normalization (June-Sep 2022)	
	Less than $30,000	Above $30,000	Less than $30,000	Above $30,000	Less than $30,000	Above $30,000	Less than $30,000	Above $30,000
Working From Home *(at least have the option to)*	32.59%	47.41%	46.56%	72.36%	51.20%	75.23%	33.20%	49.78%
Working From Home *at least one day a week*	26.23%	30.20%	45.11%	65.17%	48.03%	67.60%	25.19%	33.70%
Working From Home *at least three days a week*	12.50%	13.10%	23.45%	38.88%	28.60%	48.20%	14.04%	15.87%
Having Online Meeting *at least one day a week*	20.78%	36.33%	31.77%	62.81%	35.45%	68.27%	27.66%	54.02%
Having Online Meeting *at least three days a week*	7.13%	14.37%	11.15%	30.67%	14.90%	38.45%	9.25%	27.50%

The disparities between income groups are more pronounced than those between genders. According to table.4, High-income people (the monthly income of HK$30,000 was used as the dividing line between high and low income in this study) had much

higher rights and frequency of WFH than low-income people. About half of the High-income respondents worked from home at least three days a week during the fifth wave of the pandemic, while the percentage for Low-income is only 28.6%. However, changes in telecommuting are not sticky for either high- or low-income groups.

The traditional on-site work pattern continues to dominate in Hong Kong, in contrast to the evidence from the United States. In the US, people show a persistent preference for the “work from home” (WFH) mode mainly because of the more welcoming and comfortable working environment at home, as well as the substantial savings in commuting time. However, Hong Kong has a much lower living space per capita (only 161 square feet) than the US (721 square feet), indicating that working from home can be a suffer of confining environment, rather than the other way round. There could also be employers who are not in favor of telecommuting as they believe it is more efficient to work on-site and to communicate face-to-face. Ken Griffin, the most profitable fund manager in 2022, attributed the recent strong growth to "employees’ full-time return to office " and stressed the importance of management and interpersonal experience in career development (Berger, 2023). In June 2021, he abolished the company's telecommuting system and said: "Getting everyone back together has been very helpful in driving the business forward at Castle Investments."

Figure. 3 Behavioral change in Online Meeting Frequency

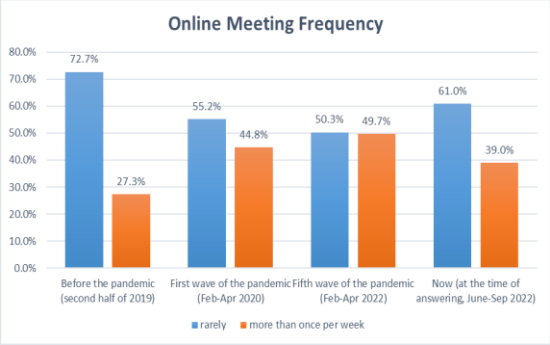
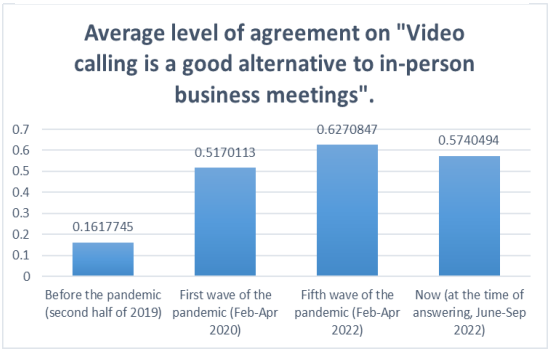


Figure. 4 Attitude change towards Video Calling



As shown in Table.4 and Figure.3, it is interesting to note that the usage of online meetings, the key instrument for telecommuting, is of strong stickiness, which remains significantly higher frequency after the pandemic than before it. Unsurprisingly, higher-income groups tend to use online meetings more regularly, and their changes are sticky. The proportion of regular online meetings usage (at least three days a week) of high-income groups in the post-pandemic period has almost doubled compared to the first half of 2019, from 14.37% to 27.5%.

As an alternative to face-to-face meetings, the online meeting is a practical tool that does not conflict with the onsite working mode. The time and physical costs of organizing and conducting an online meeting are much lower than those of a face-to-face one. Regardless of the working mode (on-site or WFH), online meetings will continue to be advantageous in the post-pandemic era and will therefore remain popular. In support of this, the results of this study depict a significant increase in agreement on “video calling is a good alternative to in-person business meetings” since the beginning

of the pandemic (Figure.4). Moreover, Hong Kong residents also have significantly higher acceptance of online meetings in social activities, amid and after the pandemic. Based on its practicality, the popularity of online meetings is a trend that we believe will be sustained and is likely to increase with further technological developments.

Travel Behavior

Contrary to fears that the pandemic might provoke a preference for less sustainable modes of commuting over the use of public transit, and despite its significant decline during pandemic peaks, public transit has remained overwhelmingly the preferred mode of commuting in the normalization period. As shown in Table. 5, while the use of public transport as the main commute mode declined relative to pre-pandemic levels by less than 2 percent (from 74.66% to 72.70%), this was primarily offset by an overall decline in travel and a slight increase in work-from-home (an increase from 2.85% to 4.92%). Moreover, based on the t-test result, the decrease in public transit is not statistically significant. In stark contrast to the evidence from the US, Hong Kong residents have not seen a shift in public transport ridership to cycling or walking since the outbreak of COVID-19. Similarly, there is only a very minor increase in the use of private vehicles (8.25% using private vehicles as a main commute mode in late 2019 as compared to 8.56% in the second half of 2022), however, this is likely to be the result of the Hong Kong Government's forward-looking restrictive policies. To reduce the potential congestion caused by the rise of private vehicle use during the pandemic, the government announced an increase in private vehicle registration taxes and annual licensing fees by as much as 15% and 30%, respectively, effective on February 24, 2021. Therefore, private vehicle use itself could have been increased more significantly, but in the end, this was not the result. In summary, the above results suggest that fears of the pandemic leading to aversion to public transport and less sustainable travel in the future are likely unfounded for commuting purposes.

Table.5 The percentage of respondents using different modes for commute trips (%)

	Before the pandemic (second half of 2019)	First wave pandemic (Feb-Apr 2020)	Fifth wave pandemic (Feb-Apr 2022)	Normalization (June-Sep 2022)	Difference (T4-T1)
Public transport	74.66	66.19	63.80	72.70	-1.96
Work/Study from home	2.85	11.31	13.71	4.92	2.07***
Walking	10.15	9.83	9.45	9.99	-0.16
Private vehicle	8.25	8.64	8.80	8.56	0.32
Taxi/Ride-hailing	2.71	2.54	2.79	2.65	-0.06
Bike	0.55	0.63	0.46	0.50	-0.05
Other means	0.83	0.83	1.00	0.94	0.11

Table.6 The percentage of respondents using different modes to travel to destinations other than work

	Before the pandemic (second half of 2019)	First wave pandemic (Feb-Apr 2020)	Fifth wave pandemic (Feb-Apr 2022)	Normalization (June-Sep 2022)	Difference (T4-T1)
Public transport	71.74	66.07	64.87	69.06	-2.68**
Walking	12.90	15.79	16.35	13.82	0.92
Private vehicle	9.84	11.55	11.59	10.40	0.55
Taxi/Ride-hailing	3.55	3.78	3.81	3.82	0.28
Bike	0.80	0.97	1.12	1.11	0.31
Other means	1.17	1.84	2.27	1.79	0.62

For non-commuter demand transport modes, however, it is a slightly different story. When choosing a mode of transport for commuting, people tend to focus on its efficiency, in other words, considering both the time and monetary cost of the trip. However, for non-commuting purposes (e.g., leisure travel), people may be more concerned with factors other than efficiency. While the proportion of public transport use in the post-pandemic period is again down slightly (2.68%) relative to the first half of 2019, this decline is statistically significant and can be explained by other modes of travel. The proportion of trips taken by walking, cycling, hailing a taxi, driving a private vehicle, or other modes all increased modestly in the normalization period, however, none of them suggests a significant difference from the pre-pandemic level. Among these, the growth in the use of walking was the most pronounced, but still not indicative of its strong stickiness, it rose to 16.35% in the most severe fifth wave of the pandemic and maintained a rise of close to 1% in the post-pandemic period compared to 12.9% in the second half of 2019. This series of changes may be due to a desire to avoid crowded public transport during non-commuting hours or for exercise purposes, but whether these behavioral changes are persistent is not sufficiently well documented in this study and we believe that this behavioral change needs to be observed on an ongoing basis. In addition, the study observed that the amount of time spent by Hong Kong people traveling declined significantly during the pandemic and returned to near pre-pandemic levels in the second half of 2022, which may have resulted from the decreasing prevalence of WFH (Figure. 6).

Figure.5 The percentage of respondents with different frequencies on public transit

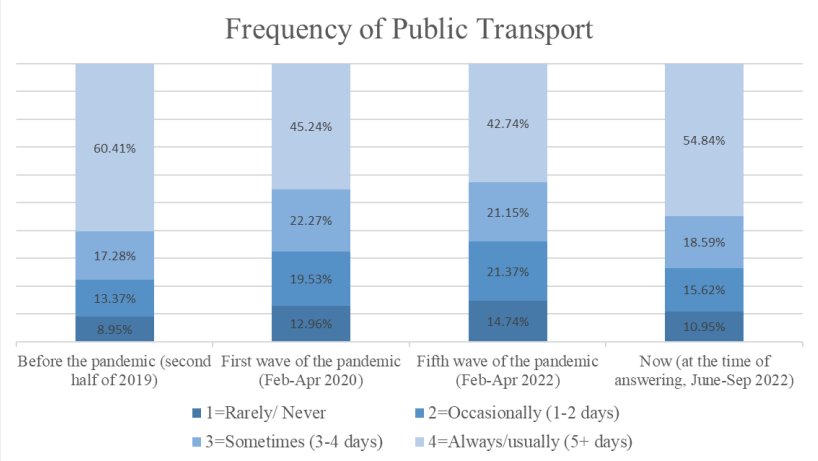
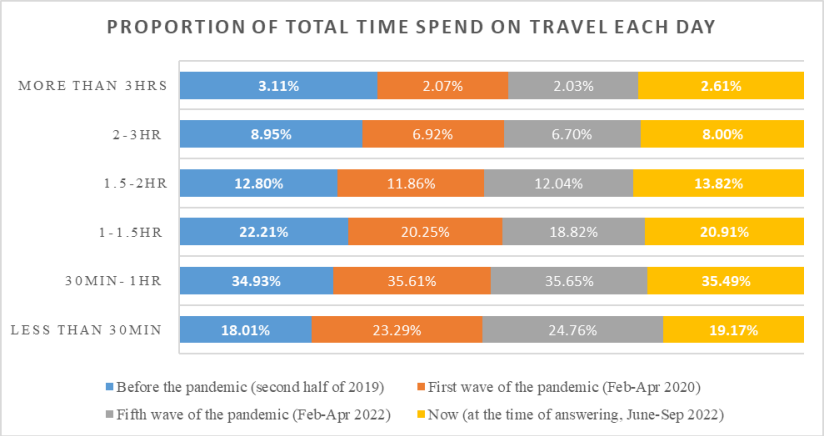


Figure. 6 Proportion of total time spent on travel per day



Consumption

Undoubtedly, the pandemic has been devastating to the consumption patterns of catering behaviors; however, it is unclear whether the changes may be more lasting. As shown in Table.7, there are only 28.25% and 22.88% of respondents dining in restaurants more than three times per week in the first and fifth wave, respectively, relative to 58.72% in the pre-pandemic period. During the first wave of the pandemic, the Hong Kong government had not yet restricted the catering service, therefore the infrequency of dine-in behavior stemmed mainly from the public's fear of the risk of infection, while the decline in the fifth wave can also be explained by catering-related containment policies. From early January 2022, as the pandemic has further worsened, the Hong Kong government has imposed stringent restrictions on dine-in restaurants, including restrictions on the number of diners (maximum 2 persons per table in Category B restaurants, 4 for Category C and 6 for Category D) and restriction on dining hours, which bans dine-in after 6 pm, and these restrictive measures have only been gradually relaxed since late April. While the percentage of those who dined in restaurants has recovered somewhat from lows during the two pandemic peaks, rates of dining in have not fully recovered, with only 41.92% dining in restaurants more than three times per week from June to September 2022, demonstrating a significant decrease of 17.09% from the pre-pandemic level.

Table.7 Catering-related consumption behaviors (in proportion)

	Before the pandemic (second half of 2019)	First wave pandemic (Feb-Apr 2020)	Fifth wave pandemic (Feb-Apr 2022)	Normalization (June-Sep 2022)	Difference (T4-T1)
Dine-in *at least once a week*	88.27%	63.37%	56.09%	80.37%	-7.90% ***
Dine-in *at least three times a week*	58.92%	28.42%	23.05%	41.83%	-17.09% ***
Order food for pick up *at a restaurant at least once a week*	53.49%	67.79%	70.88%	70.32%	16.83% ***
Order food for pick up *at a restaurant at least three times a week*	19.37%	34.62%	40.64%	32.84%	13.47% ***
Order food for delivery *from a restaurant at least once a week*	30.27%	40.74%	43.15%	40.12%	9.85% ***
Order food for delivery *from a restaurant at least three times a week*	9.02%	17.22%	19.93%	14.43%	5.41% ***

Notably, while both rates of ordering for pick-up and ordering for delivery increased alongside this decline in dine-in behaviors, the growth in ordering for pick-up has been much larger than the increase in ordering for delivery. Specifically, the proportion of respondents ordered pick-up more than once a week increased from 53.49% before the pandemic to 70.32% in mid-2022; while the proportion for food delivery rose from 30.27% to 40.12% in the normalization period. Notably, both pick-up and food delivery for at least once a week present strong stickiness in changes since the pandemic, suggesting that both of them have likely become the new normal in daily life patterns. As for frequent (at least three times a week) catering behavior, the proportion for food pick-up increased 13.47%, much higher than the 5.41% for food delivery. The results suggest that ordering for pick-up rather than delivery has been the most significant substitute for in-restaurant dining, indicating better prospects for recovery of dining establishments, given their continued direct contact with patrons and the suggestion that most patrons are still willing to travel to restaurant premises to pick up their meals.

In terms of shopping consumption patterns, while Hong Kong residents are retaining the traditional in-store mode, they are also increasingly embracing online shopping as an alternative. The little change in Hong Kong residents' behavior on buying groceries in stores during the pandemic cannot persist, which recovers in the normalization period (91.40% for at least one day a week, 47.89% for at least three days a week), to reach the levels observed in the second half of 2019 (91.07% for at least one day a week, 49.77% for at least three days a week). In the meanwhile, online shopping for both groceries and other items has grown rapidly during the pandemic, and this growth has been extremely sticky, with the proportion of respondents who order groceries at least three days per week before the pandemic almost doubling to 18.11% between June and September 2022 (for other items from 10.14% pre-pandemic to 15.95% post-pandemic). This suggests that Hong Kong residents are likely to have adopted online shopping as part of their daily habits since the pandemic.

Table.8 Shopping-related consumption behaviors (in proportion)

	Before the pandemic (second half of 2019)	First wave pandemic (Feb-Apr 2020)	Fifth wave pandemic (Feb-Apr 2022)	Normalization (June-Sep 2022)	Difference (T4-T1)
Shop for groceries in a store *(e.g. convenience store, supermarket) at least once a week*	91.07%	88.01%	85.97%	91.40%	0.33%
Shop for groceries in a store *(e.g. convenience store, supermarket) at least three times a week*	49.77%	40.58%	39.96%	47.89%	-1.88%
Order groceries online for delivery *(to your home or a nearby pick-up point) at least once a week*	37.22%	48.35%	52.08%	50.03%	12.81% ***
Order groceries online for delivery *(to your home or a nearby pick-up point) at least three times a week*	9.68%	17.55%	21.02%	18.11%	8.43% ***
Order other items (not including groceries) online for delivery *at least once a week*	41.93%	49.01%	50.96%	51.75%	9.82% ***
Order other items (not including groceries) online for delivery *at least three times a week*	10.14%	14.39%	16.93%	15.95%	5.81% ***

Nevertheless, increases in both catering and shopping delivery thus far appear to be sticky, with the number of those ordering meal delivery, grocery delivery, and other items delivery more than once per week in mid-2022 roughly on par with the numbers during the two peaks of the pandemic (see Figure 7 and Figure 8). These results suggest that the delivery industry may remain a more important part of the Hong Kong economy than before the pandemic.

Figure 7. Behavioral change in the frequency of food delivery

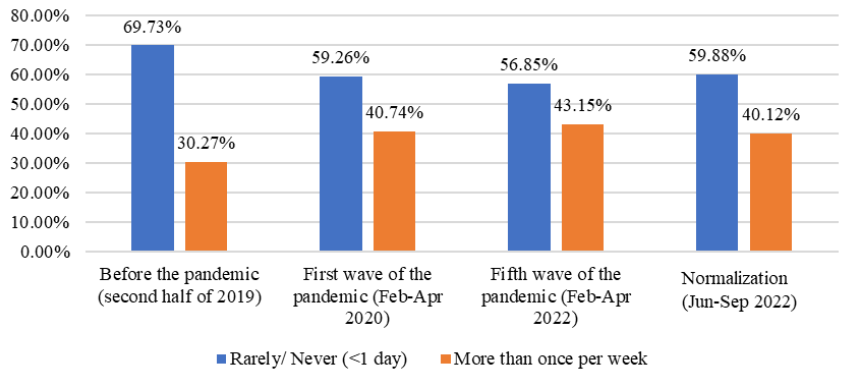
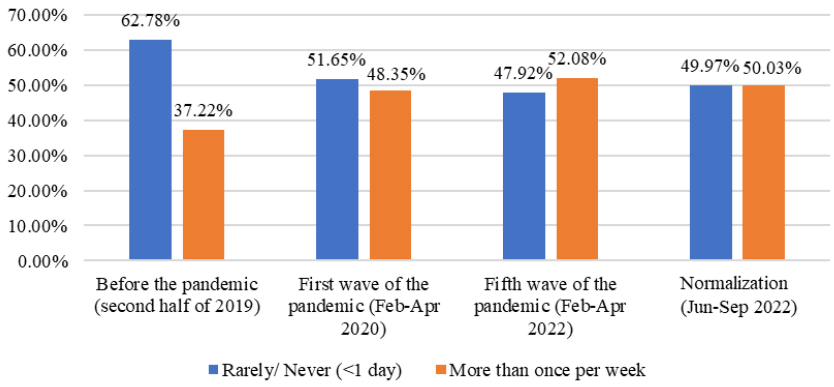


Figure 8. Behavioral change in frequency of online grocery shopping (for home delivery)



Values

Respondents in this study were also asked about their attitudes to several statements, including video calling as a substitute for in-person meetings, consumerism, environmental attitudes and health awareness. Notably, the attitudes “strongly disagree,” “somewhat disagree,” and “neutral” are given values of -2, -1, and 0, and vice versa. As shown in Table 9, attitudes toward video calling have changed significantly since the outbreak of the pandemic. Specifically, the average attitudes towards video calling as a substitute for in-person business meetings have shifted from near-neutral (0.16) to near-"somewhat agree" (0.57) post-pandemic, while attitudes towards it as a substitute for visiting friends and family have shifted from negative (-0.54) to near-neutral (-0.18). More importantly, the average values towards agreement in the post-pandemic period are on par with the ones amid the pandemic, indicating the shifts in attitudes are persistent, which explains why online meetings are still popular these days.

Table. 9 Summary statistics on the Average Level of Agreement on several statements

**Noted: -2 = strongly disagree; -1 = somewhat disagree; 0 = neutral attitude; 1 = somewhat agree; 2 = strongly agree					
	Before the pandemic (second half of 2019)	First wave pandemic (Feb-Apr 2020)	Fifth wave pandemic (Feb-Apr 2022)	Normalization (June-Sep 2022)	Difference (T4-T1)
Video calling is a good alternative to in-person business meetings	0.16	0.52	0.63	0.57	0.41***
Video calling is a good alternative to visiting friends and family	-0.54	-0.17	-0.07	-0.18	0.36***
Don't like to buy things more than I need	0.70	0.70	0.73	0.79	0.09**
Committed to an environmentally-friendly lifestyle	0.56	0.53	0.56	0.61	0.04
I don't like crowded spaces	0.61	1.08	1.18	1.07	0.46***
The cleanliness of stores is important to me	1.05	1.33	1.41	1.39	0.34***
I am health conscious	0.83	1.03	1.12	1.14	0.30***

The past literature is fraught with controversy regarding the direction of change in people's consumerism after experiencing a disaster or recession; Kennett-Hensel et al.

(2012) found that survivors of Hurricane Katrina, aware of the possibility of a sudden loss of material wealth, generally purchased fewer and cheaper things even after their incomes returned to normal. On the other hand, Debevec et al. (2013) note the lasting effects of the sub-prime mortgage crisis and subsequent Great Recession on the generation that came of age during this period, but find that rather than reducing consumerism, the experience of the crisis reduced frugality and generated attitudes of full enjoyment of life. However, the findings of this study show that after a prolonged economic downturn, people are less consumerist in general. People's attitudes towards frugal spending in Hong Kong did not change much during the pandemic; instead, they only rose significantly after the pandemic ended. This is probably because Hong Kong's economy has been overwhelmed after being hit by the riots in 2019 and the two-and-a-half-year-long pandemic that started in 2020 in quick succession. According to the Hong Kong SAR Government's Census and Statistics Department, Hong Kong's GDP fell by 4.6% year-on-year in the third quarter of 2022. In this ongoing economic downturn, it is natural for Hong Kong people to have more pessimistic expectations for the future and thus a more frugal outlook on consumption. However, the sustainability of this change remains to be seen, as Hong Kong's economic expectations may radically improve with the sudden relaxation of Mainland China's epidemic control in December 2022, which may again change the public's spending mindset.

In the process of confronting the health threats posed by COVID-19, Hong Kong people became more averse to crowded spaces, had higher expectations of hygiene in shops, and were more concerned about their health. These attitudinal changes all seem to be highly sticky, with the average values remaining more or less the same in the latter three stages. This set of changes testifies to past scholarly speculation that COVID-19 will make space, cleanliness, and health a long-term priority (Roggeveen & Sethuraman, 2020). Interestingly, compared to other attitudes' significant changes, Hong Kong people's attitudes towards environmentally friendly lifestyles did not change as much, insignificant rising from 0.56 in the second half of 2019 to 0.61 in the normalization period. Knowledge of the above changes in attitudes and values will help scholars and policymakers better understand everyday behavioral changes in the post-pandemic era and their likelihood of being persistent.

Technology and Internet

While the pandemic has reshaped the daily behaviors of residents, it has also raised valuable opportunities for the spread of emerging technologies, among which the behavioral changes associated with Internet technology cannot be neglected. As evident in Table. 10, the proportion of both high-frequency (at least five days a week) Internet browsing through and high-frequency social media (e.g., WhatsApp, WeChat, Facebook, Twitter, Instagram) usage continues to rise from high base numbers, albeit by a modest margin. As for the usage of video calling or online conferencing technology for work or personal purposes, the increase is much more significant and of strong stickiness, with the proportion of using it at least one day per week, rising from 38.86%

in the second half of 2019 to 61.27% post-pandemic.

Table. 10 Summary statistics on Internet usage behaviors

	Before the pandemic (second half of 2019)	First wave pandemic (Feb-Apr 2020)	Fifth wave pandemic (Feb-Apr 2022)	Normalization (June-Sep 2022)
Browse the internet on a computer at least five times a week	58.16%	61.90%	63.83%	62.70%
Use of video calling/ online conferencing technology (including for work and personal reasons) at least once a week	38.86%	61.77%	65.25%	59.12%
Use digital payment systems (e.g Octopus/credit cards/Alipay) at least five times a week	49.40%	51.46%	55.64%	61.27%
Use social media (e.g. WhatsApp, Wechat, Facebook, Twitter, Instagram) at least five times a week	80.37%	82.23%	83.49%	83.52%

Another major finding is that the proportion of high-frequency digital payments (e.g., Octopus, credit card, Alipay, and WeChat pay) has been continuous, from 49.4% in the pre-pandemic period to 55.64% during the fifth wave of the pandemic and then to 61.27% in the post-pandemic period. It indicates that the popularity of e-payments is still in progress and, while already an important part of citizens' daily behavior, is likely to take on even greater importance in the future. The popularity of digital payments is influenced by the growth of online shopping and the potential health threats of cash payments during the pandemic, in addition to its outstanding convenience.

Psychological health

As the pandemic has spread worldwide, people around the world have experienced a surge in psychological distress. For example, an online survey in Iran found that individuals were at high risk of psychological distress and insomnia due to the stress of the COVID-19 outbreak (Lin et al., 2020); 13.6% of US adults reported symptoms of severe psychological distress in April 2020, relative to 3.9% in 2018 (McGinty et al., 2020); and the UK's clinically population prevalence of significant levels of psychological distress increased from 19% in 2018-19 to 27% in April 2020 (Pierce et al., 2020).

Table. 11 Summary statistics on the Average Frequency of Symptoms of Stress Overload

**Noted: the frequency is measured on how often did the respondents have the following situations per week on average							
	Before the pandemic (second half of 2019)	First wave pandemic (Feb-Apr 2020)		Fifth wave pandemic (Feb-Apr 2022)		Normalization (June-Sep 2022)	
	Average Frequency (as the baseline)	Average Frequency	Increase in Percentage	Average Frequency	Increase in Percentage	Average Frequency	Increase in Percentage
Feel unable to become enthusiastic about anything	1.36	1.92	**41.53%**	2.21	**62.70%**	1.96	**44.04%**
Feel that life was meaningless	0.87	1.25	**43.53%**	1.47	**68.86%**	1.33	**53.41%**
Feel panic	0.67	1.44	**115.54%**	1.60	**139.63%**	1.15	**72.66%**
Dyspnoea (e.g. rapid breathing, difficulty breathing without physical activity)	0.30	0.48	**61.66%**	0.61	**105.43%**	0.54	**82.51%**
Find it difficult to relax	1.04	1.55	**48.20%**	1.72	**65.13%**	1.47	**40.99%**
Tends to overreact to situations	0.80	1.26	**58.55%**	1.37	**72.25%**	1.14	**43.50%**

Although the impact of COVID-19 on stress and psychological health is widespread, profound, and detrimental, Manchia et al (2022) found surprising levels of resilience in the population through an analysis of hundreds of relevant literature. In other words, the stress caused by the COVID-19 pandemic was able to recover rapidly as the pandemic became less severe or gone. However, this study shows a contradictory story. The average frequency of stress-overload symptoms increased significantly during the first wave of the pandemic and reached even higher levels during the fifth wave of the pandemic. Using the pre-pandemic period (the second half of 2019), as the baseline, the frequency of Dyspnoea emergence increased by 61.7%, 105.4%, and 82.5% during the latter three phases, respectively; while the average frequency of self-reported symptoms for all relevant symptoms increased by 61.5% during the first wave of the pandemic and by 85.7% during the fifth wave. Although this increase dropped to 56.2% during the post-pandemic phase, it was still well above pre-pandemic levels. It gives a red flag that the rise in psychological stress in Hong Kong as a result of the COVID-19 pandemic might have an exceptionally strong stickiness. As stress leads to greater dissatisfaction (Andreasen, 1984), the persistence of the unusually high level of stress, will have serious negative impacts on the daily activities and behavior of Hong Kong residents amid the post-pandemic era.

4.2 Factors Mediating the Behavioral Changes

Figures 9 to 12 visualize the results for each SEM behavior change model. While in each model for different behavior groups, all four dependent variables are simultaneously incorporated into the models, segregating the graphs for each dependent variable facilitates visualization and interpretation. In comparison to the comprehensive SEM framework depicted in Figure 2, the result plots omit T1 variables and sociodemographic factors, and only display coefficients that achieve statistical significance at least at a 95% confidence level. Figure 9 demonstrates the results for the catering behavior change model (Panel A for dining in frequencies, Panel B for taking away frequencies, and Panel C for food delivery frequencies); Figure 10 for the consumption behavior change model (Panel A for offline grocery frequencies, Panel B for online grocery frequencies, and Panel C for online shopping frequencies); Figure 11 for daily travel behavior change model (Panel A for driving along frequencies, Panel B for carpooling frequencies, Panel C for taxi/ride-hailing frequencies and Panel D for public transit usage frequencies); Figure 12 for commuting mode change model (Panel A for private vehicle percentage, Panel B for public transit percentage and Panel C for working from home percentage).

Our models estimate both the direct impacts of neighborhood covid risks and economic circumstances on behavior changes, and their indirect impacts via stress, attitudes and values, and technology accessibility. Hence, before diving into the mediation effect of the intermediate variables, the results first examine how residential risks and economic circumstances directly affect people's behavior changes.

The direct impacts of residential COVID risks and economic circumstances

Surprisingly, residential COVID risks exert limited direct impacts on people's behavior. Specifically, the T4 risk level is found to have a statistically significant direct impact only on online shopping behavior and private vehicle commuting usage. T4 risk is positively related to online shopping behavior change. One standard deviation (SD, hereafter) increase in the T4 risk level is related to a 0.05 SD increase in online shopping frequency growth from T1 to T4. In the case of commuting behavior, the T4 risk level has a statistically significant and negative direct impact on private vehicle usage percentage. One SD increase in confirmed COVID-19 cases in T4 contributes to a 0.07 SD decrease in the percentage change of private vehicle commuting trips.

On the contrary, changes in economic circumstances, i.e., the changes in monthly household income, have a direct impact on most behavior changes. The analysis reveals that most behavior change variables are directly influenced by changes in monthly household income level. Specifically, one standard deviation (SD) decrease in monthly household income change leads to a 0.07 SD decrease in dine-in frequency growth, 0.06 SD decrease in taking away frequency growth, and 0.05 SD decrease in food delivery frequency growth. As for daily travel behavior changes, one standard deviation (SD) decrease in monthly household income change from the mean contributes to 0.05

SD decreases in driving alone frequency growth, 0.11 SD decreases in carpooling frequency growth, 0.01 SD decreases in taxi/ride-hailing usage frequency growth, and 0.11 SD decreases in public transit usage frequency growth. It suggests that worse economic circumstances during the pandemic would directly discourage catering and daily travel behaviors.

The mediation effect of changes in stress levels for economic circumstances
Change in stress levels during the pandemic is an important mediation variable only for economic situations. The models show that regardless of the sample, a higher increase in monthly household income levels during the pandemic would lead to a decrease in stress level changes: one standard deviation (SD) decrease in monthly household income change from the mean leads to a 0.1 SD increase in stress level growth. Note that the residential COVID risk doesn't have a positive impact on changes in stress levels. It indicates that a higher stress level growth rate during the pandemic is more attributed to a limping economic situation, yet less influenced by objective COVID risks in the neighborhood.

A higher change in stress levels discourages visits to crowded places in general. For catering and consumption behaviors, one SD increase in stress level change is associated with a 0.05 SD decrease in dinging in frequency growth, 0.08 SD increase in taking away frequency growth and 0.09 SD increase in online grocery frequency growth. For traveling behaviors, one SD increase in stress level change is associated with a 0.04 SD decrease in daily carpooling usage frequency growth. Nonetheless, it's also observed that a greater change in stress level is negatively associated with working-from-home percentage among workers: one SD increase in stress level change is associated with a 0.08 decrease in working-from-home percentage growth. It implies that people with a higher increase in stress levels during the pandemic tend to work from home less. The negative relationship might be explained by the crowded residential spaces, lack of dedicated home offices, and hence unpleasant working environment at home, which people with stress-prone personalities tend to avoid.

The mediation of changes in attitudes and values
Changes in attitudes/values are key mediating factors in all models. Specifically, only environmentalism and aversion to crowdedness serve as intermediate factors for both residential COVID risks and economic circumstances among the full sample, while other attitude/value variables only mediate the impact of monthly household income changes.

Changes in **environmental awareness** is positively influenced by neighborhood risks but negatively impacted by changes in monthly household income. A higher level of residential pandemic risks at T2 contributes to a stronger environmentalism. In specific, one SD increase in the T2 risk level leads to 0.06 increases in environmentalism tendency growth. The change in environmentalism is negatively associated with monthly household income: one SD increase in monthly household income change

contributes to a 0.06 SD decrease in environmentalism. Meanwhile. one SD increase in environmentalism tendency shift leads to 0.06 SD increases in physical grocery shopping frequency growth. It suggests that people living in neighbourhoods with a higher level of COVID risk or experiencing a larger drop in monthly household income would develop a greater awareness about environmental protection, which would encourage a higher frequency of physical visits to grocery stores. However, the pattern is missing among the working population.

Another crucial intermediate attitude factor between COVID risks and behavior changes is **crowdedness aversion**. The change in aversion to crowds is positively correlated with neighborhood risks while negatively related to monthly household income levels, among the full sample. The model suggests that on average, one SD increase in T2 risk levels contributes to 0.05 SD increases in the crowdedness aversion changes, and one SD decrease in monthly household income leads to a 0.04 SD increase in the crowdedness aversion changes. One SD increase in crowdedness aversion change leads to 0.12 SD decreases in dining frequencies while 0.05 SD increases in taking away frequency growth, 0.07 SD decreases in physical visit frequencies to grocery stores while 0.07 SD increases in online grocery frequency growth, 0.05 decreases in daily carpooling frequency growth, and 0.08 SD decreases in daily public transit usage frequency growth. There is a consistent pattern of the mediation effects of the crowdedness aversion: higher residential COVID risks or a larger-than-average decrease in monthly household income would increase people's dislike for crowdedness, while a higher level of crowdedness aversion leads to avoidance of physical visits to public places and participation in online activities.

Among the working population, while crowd aversion is not influenced by residential risk level nor monthly household income changes, it still has a statistically significant impact on public transit and private vehicle commuting trips. It's found that one SD increase in the aversion attitude leads to 0.06 decreases in public transit commuting trip percentage growth and 0.06 increases in private vehicle commute trip percentage growth. It resembles the pattern discovered in the full sample.

A higher increase in monthly household income would relieve an increase in **thriftiness**: one SD increase in monthly household income change contributes to about 0.06 to 0.07 SD decrease in changes of thriftiness. At the same time, a higher level of increase in thriftiness is associated with a slower frequency growth in dine-in, food delivery, physical visits to grocery stores, online shopping, carpooling, and taxi/ride-hailing usage. In specific, one SD increase in thriftiness contributes to a decrease in frequency growth by 0.05 SD for dine-in frequencies, 0.06 SD for food delivery, 0.05 SD for offline grocery, 0.07 SD for online shopping, 0.04 SD for carpooling, 0.05 SD for taxi/ride-hailing usage. As people become more cautious with their money due to the economic downturn, they tend to decrease their catering, consumption and travel behavior in general. The statistically significant impact of thriftiness on commuting mode choice is not observed.

Attitudes favoring videocall over face-to-face communication for social occasions also mediate the impact of monthly household incomes on dine-in frequencies. One SD increase in monthly household income change contributes to a 0.07 SD decrease in the preference for substituting personal communication with online video calls. At the same time, as people become more into videocall as a tool to communicate with their friends, the growth of dine-in frequency decreases: one SD increase in attitude favoring videocall leads to a 0.09 SD decrease in the growth of dine-in frequency. As the desire for face-to-face social interactions with friends or families decreases due to the worsening economic situation, the dine-in frequencies further decrease as a result.

On the contrary, the **attitude favoring videocall over face-to-face communication for work purposes** doesn't have a mediation effect on COVID risks and the economic situation. However, it's found that it has statistically significant impacts on travel behavior. One SD increase in the preference growth of substituting professional communication with online video calls contributes to a 0.07 SD decrease in both daily public transit frequency growth among the full sample and public transit commuting trips among the working sample. Besides, a 0.05 SD decrease in the percentage growth of private vehicle commuting trips was observed among the working sample. However, the growth of the working-from-home percentage is positively associated with such preferences: One SD increase in the preference growth of substituting professional communication with online video calls contributes to 0.06 increases in the growth of the working-from-home percentage.

Hence, the preference for videocall over face-to-face interactions, regardless of personal or professional occasions, has further reduced movements and increased the tendency to stay at home.

Health consciousness and **hygiene concerns** about local stores both measure people's sensitivity to health conditions and potential health hazards. They also mediate the impacts of economic circumstances on people's behavior changes among the full sample, but in an unexpected way. Both are negatively related to monthly household income changes. One SD decrease in monthly household income growth is associated with 0.06 SD increases in health consciousness changes and 0.05 SD increases in hygiene concerns. The larger increase in health consciousness and hygiene concerns due to a larger decrease in monthly household income might be attributed to increasing perceived health risks and worry about a high health expenditure during the pandemic.

A higher level of health consciousness is positively related to a higher frequency growth of dine-in, taking away, and offline grocery: one SD increase in health consciousness changes is related to 0.07 SD increases in dine-in frequency growth, 0.05 SD increases in taking away frequency growth, and 0.08 SD increases in offline grocery frequency growth. Hygiene concern for local stores is positively related to dine-in, food delivery and daily carpooling: one SD increase in hygiene concern is related to 0.06 SD increases

in dine-in frequency growth, 0.04 SD increases in food delivery frequency growth, and 0.08 SD increases in daily carpooling frequency growth. The positive relationship between a higher level of sensitivity to health conditions and potential health hazards and more outdoor activities is unlooked-for. A possible explanation for such observation might be that people who engage in more outdoor activities are more concerned about their health condition and the hygiene condition of stores during the pandemic.

The mediation effect of health consciousness and hygiene concerns about local stores disappear among the working sample, yet the impact of hygiene concerns is observed. A higher increase in hygiene concern about local stores is positively related to a higher increase in working from home percentage: one SD increase in hygiene concern is related to 0.06 SD increases in working from home percentage growth. It suggests that people with a greater worry about local store hygiene conditions would stay more time at home for work.

The impacts of technology accessibility and familiarity

For technology accessibility and familiarity, only **videocall frequency** growth serves as a mediation factor between the exogenous factors and the behavior changes of interest. Among the full sample, one SD increase in the growth of monthly household income is associated with a 0.04 SD increase in the frequency growth of videocall usage. At the same time, a higher growth rate of videocall frequency is negatively associated with offline grocery frequency and daily public transit usage, and positively associated with behavior like taking away, online grocery, and online shopping. One SD increase in videocall frequency changes contributes to a 0.04 SD decrease in both dine-in frequency growth and public transit frequency growth, and an increase in frequency growth by 0.05 SD for take away, by 0.08 SD for online grocery, and by 0.07 SD for online shopping. Among the working population, videocall frequency growth mediates the impact of T2 covid risk on working from home. It's observed that one SD increase in T2 COVID risk leads to 0.07 SD increases in video-calling frequency growth, and one SD increase in video-calling frequency growth contributes to a 0.08 increase in working-from-home frequency growth.

As another measurement for digital technology familiarity, **internet usage frequency** also exerts statistically significant impacts on the different behaviors of interest, though it doesn't mediate between the exogenous variables and behavior changes. One SD increase in internet usage frequency growth leads to a 0.04 SD decrease in dine-in frequency growth and a 0.07 SD decrease in carpooling frequency growth, an increase in frequency growth by 0.04 SD for food delivery, by 0.01 SD for online grocery, by 0.07 SD for online shopping, and by 0.07 SD for taxi/ride-hailing frequency growth.

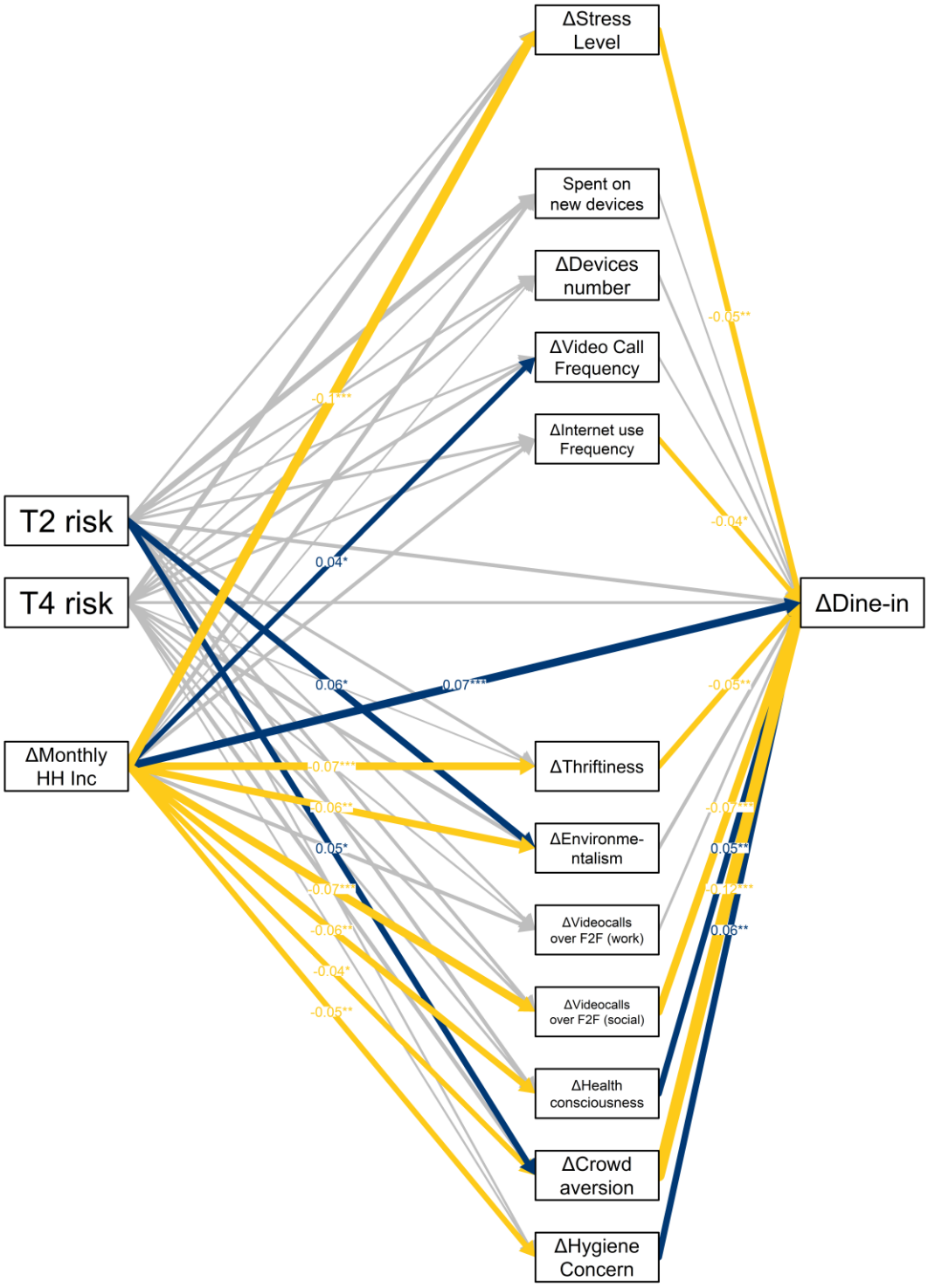
Notably, all models suggest that the influence of changes in monthly household incomes and neighborhood COVID risks on changes in technology accessibility is not statistically significant. Yet, it's observed that the **expenditure on technology devices** and the increase in the **number of devices** also have statistically significant impacts on

certain behavior changes. Higher expenditure on technology devices is positively associated with more online shopping behavior among the full sample. One SD increase in expenditure on digital devices is associated with a 0.05 SD increase in online shopping frequency growth. For the working population, having more technology devices is positively associated with working-from-home frequency growth: one SD increase in the number of digital devices is associated with a 0.05 SD increase in working-from-home frequency growth.

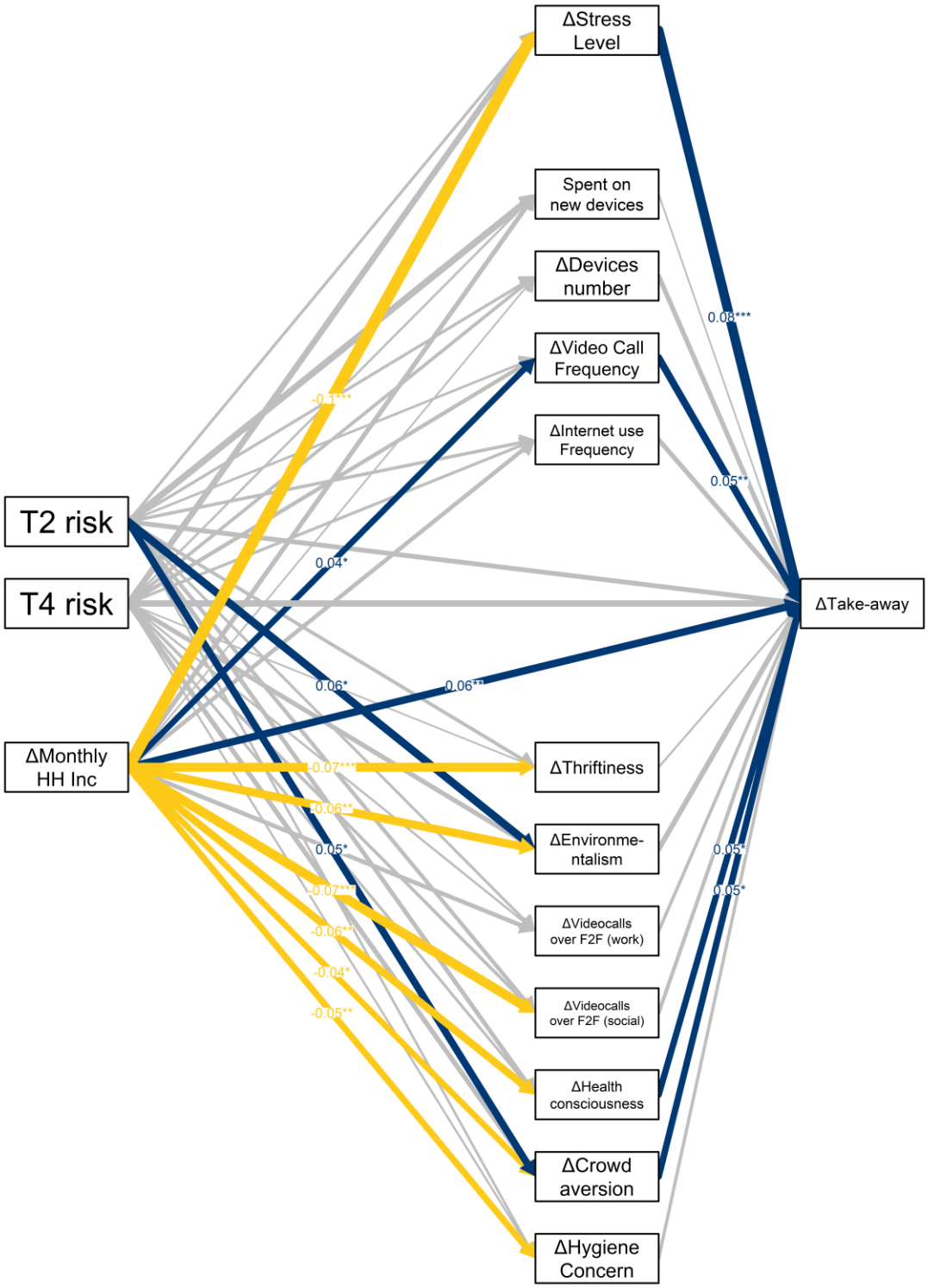
In general, as people get more reliant on digital technologies and the internet and as technology accessibility grows, they tend to rely more on online platforms for daily needs or work.

Figure 9. SEM results for catering behavior. (Note: Blue arrows indicate positive and statistically significant at 95% CI level coefficients, yellow arrows suggest negative and statistically significant at 95% CI level coefficients, and gray arrows represent statistically insignificant coefficients. * indicates p<0.05. ** indicates p<0.01. ***indicates p<0.001.)

Panel A. Changes in dine-in frequency.



Panel B. Changes in take-away frequency.



Panel C. Changes in food delivery frequency.

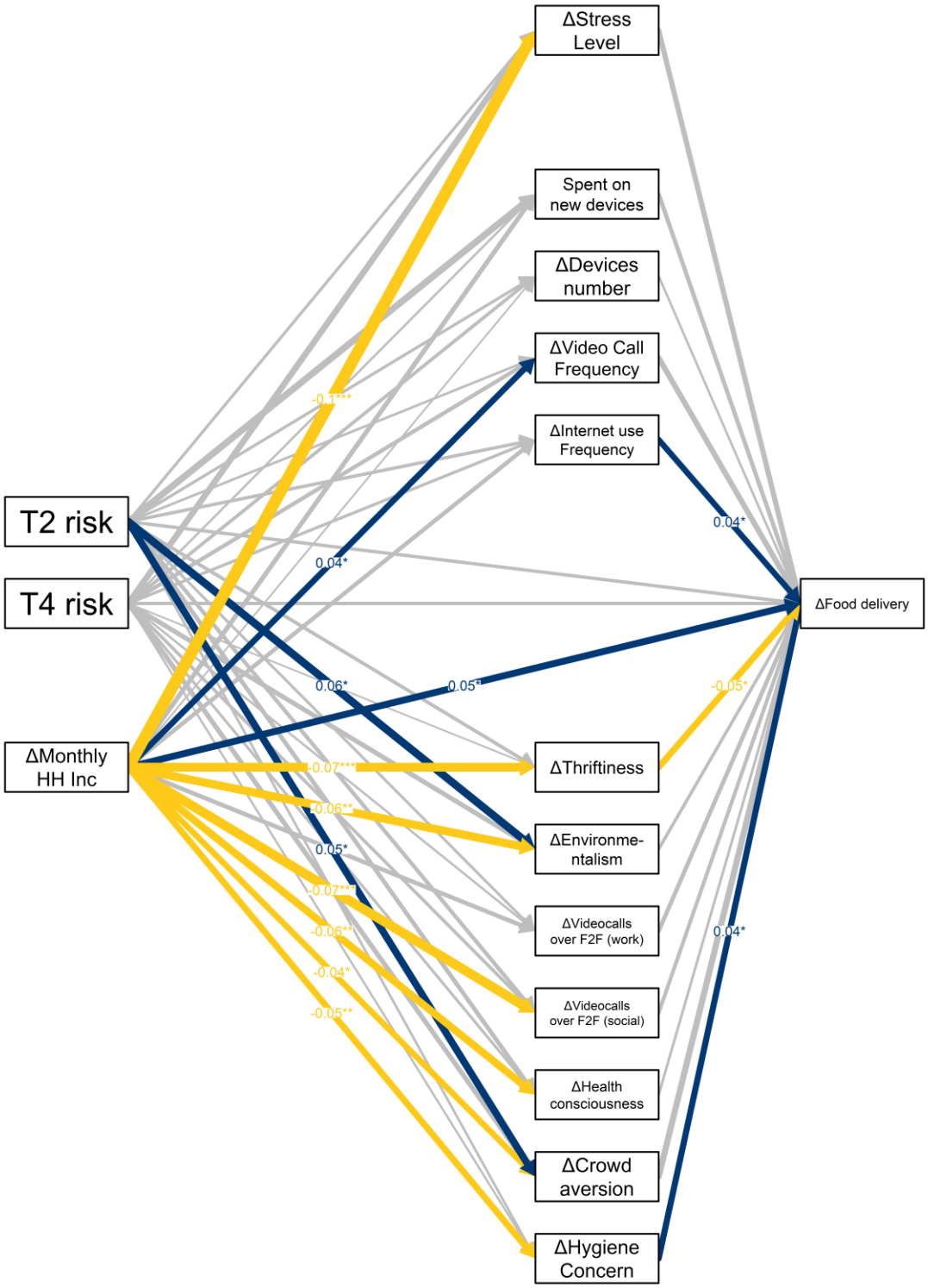
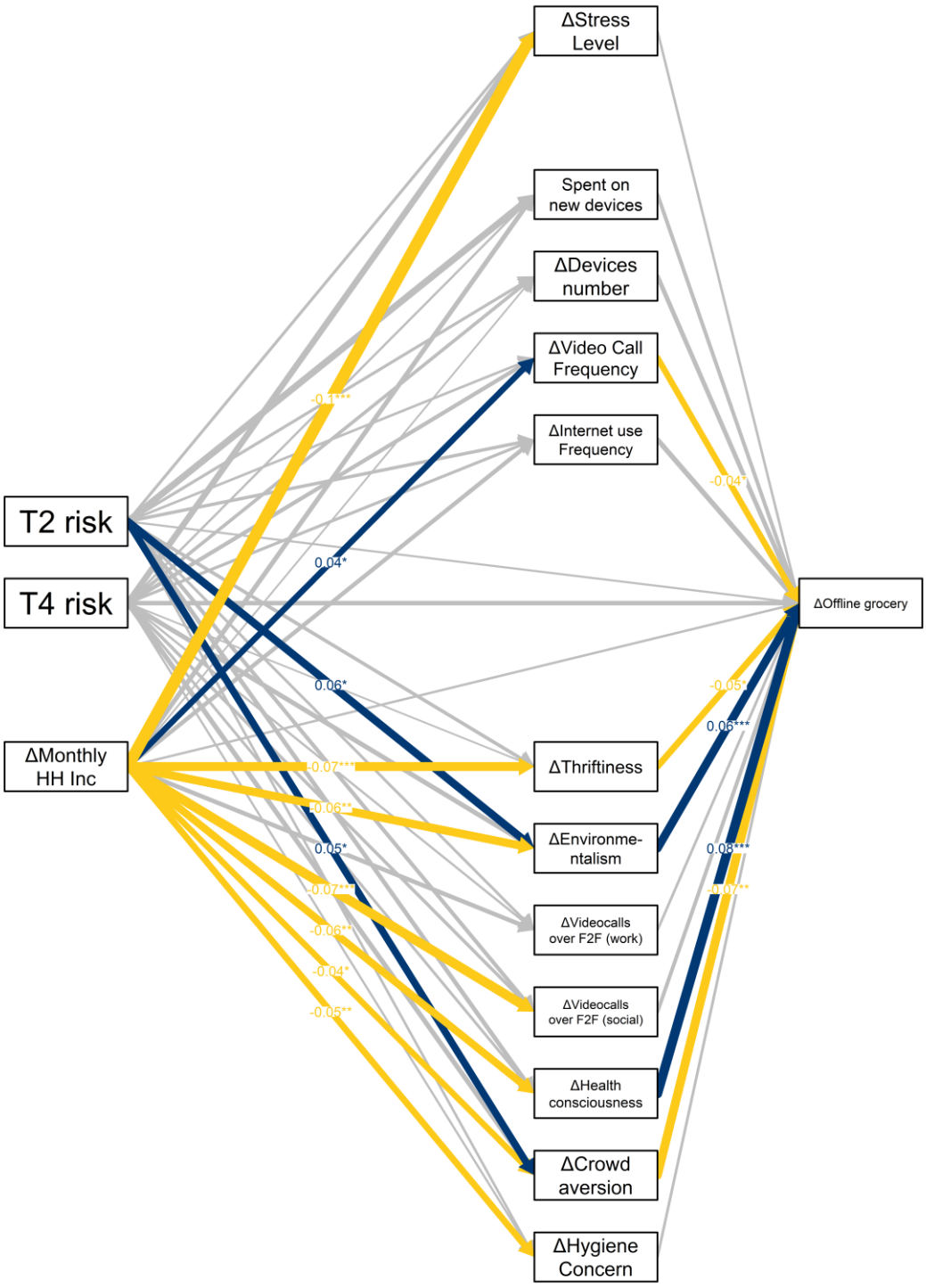
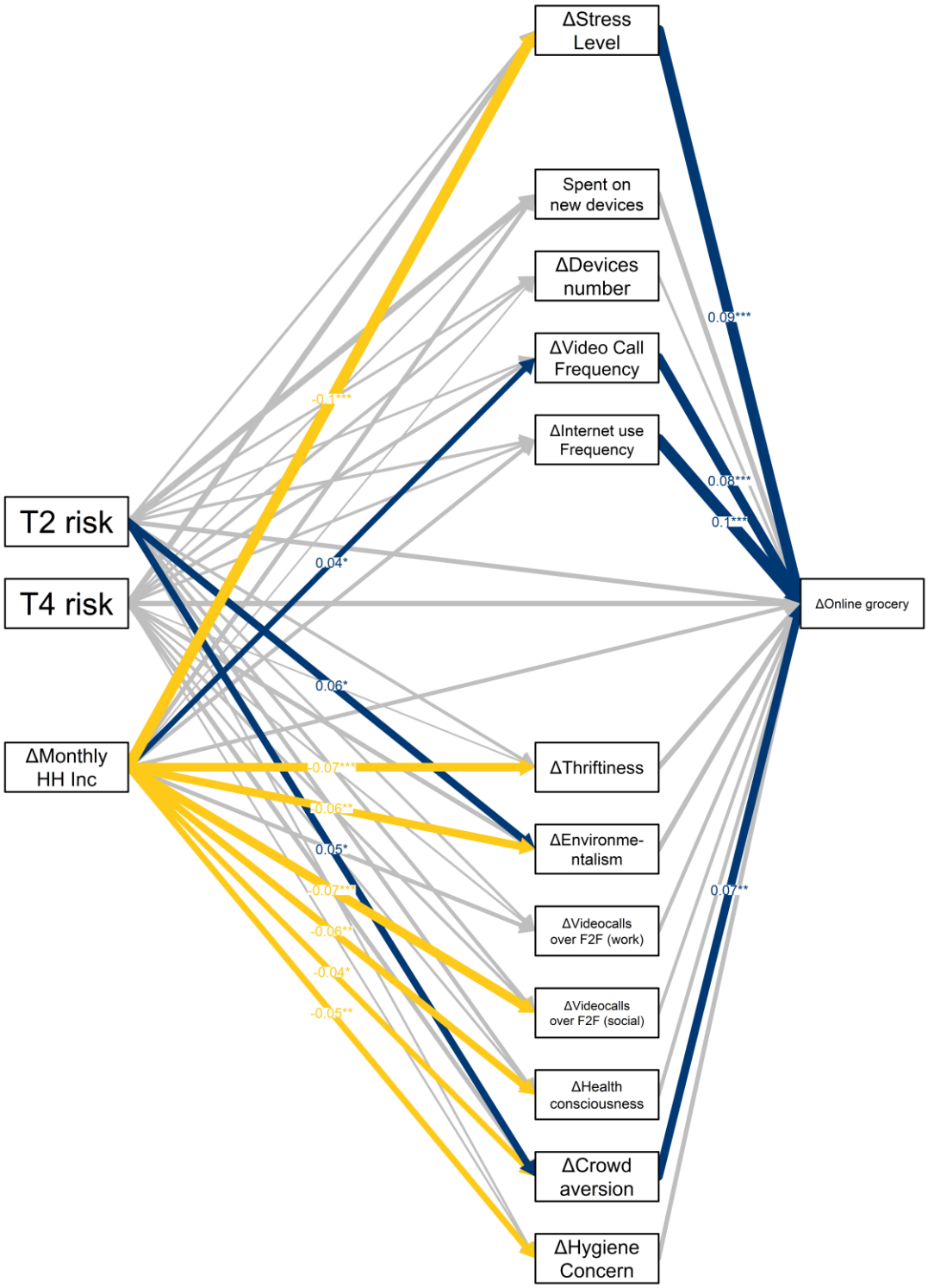


Figure 10. SEM results for consumption behavior (Note: Blue arrows indicate positive and statistically significant at 95% CI level coefficients, yellow arrows suggest negative and statistically significant at 95% CI level coefficients, and gray arrows represent statistically insignificant coefficients. * indicates p<0.05. ** indicates p<0.01. ***indicates p<0.001.)

Panel A. Changes in offline grocery frequency.



Panel B. Changes in online grocery frequency.



Panel C. Changes in online shopping frequency.

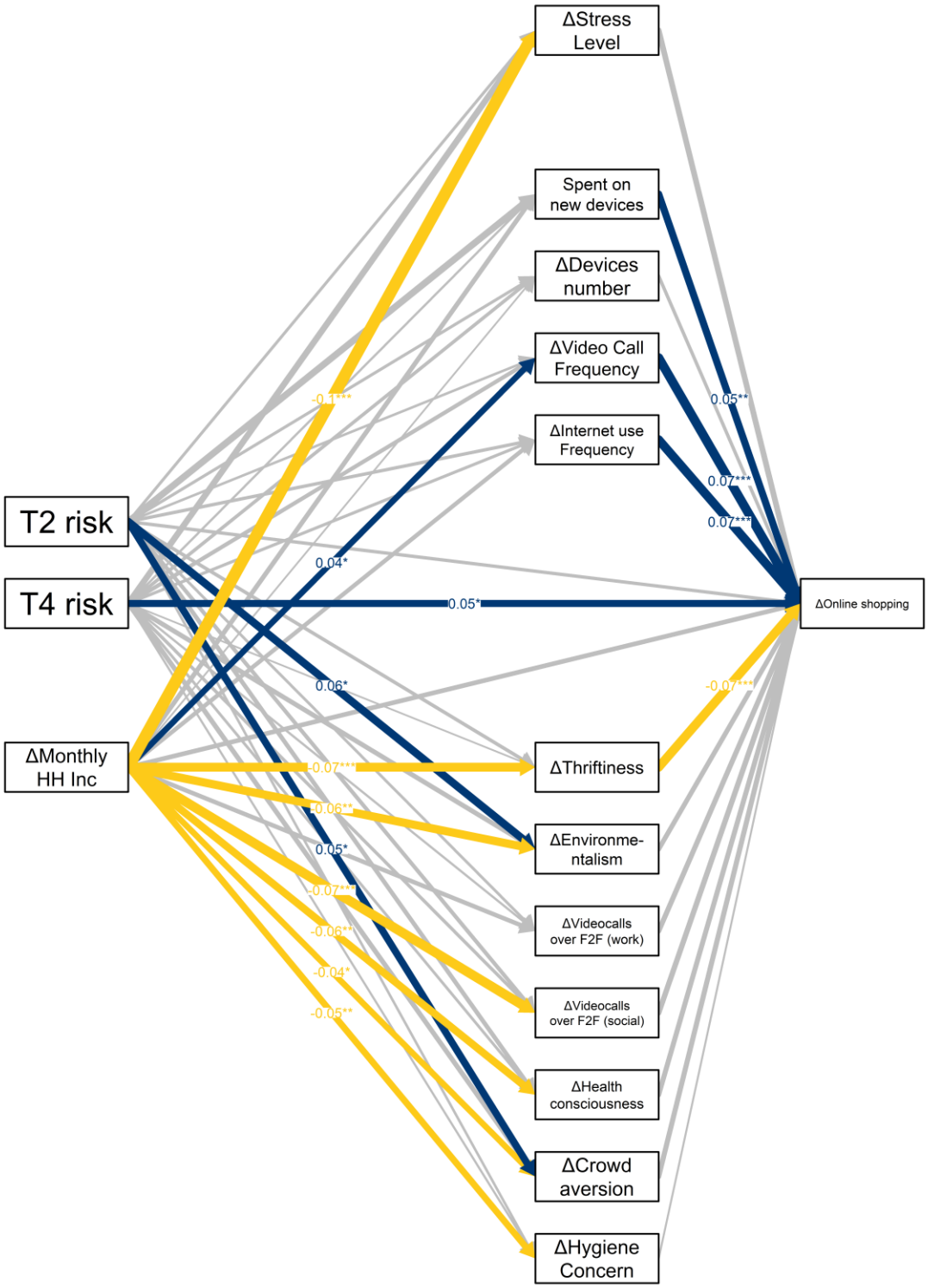
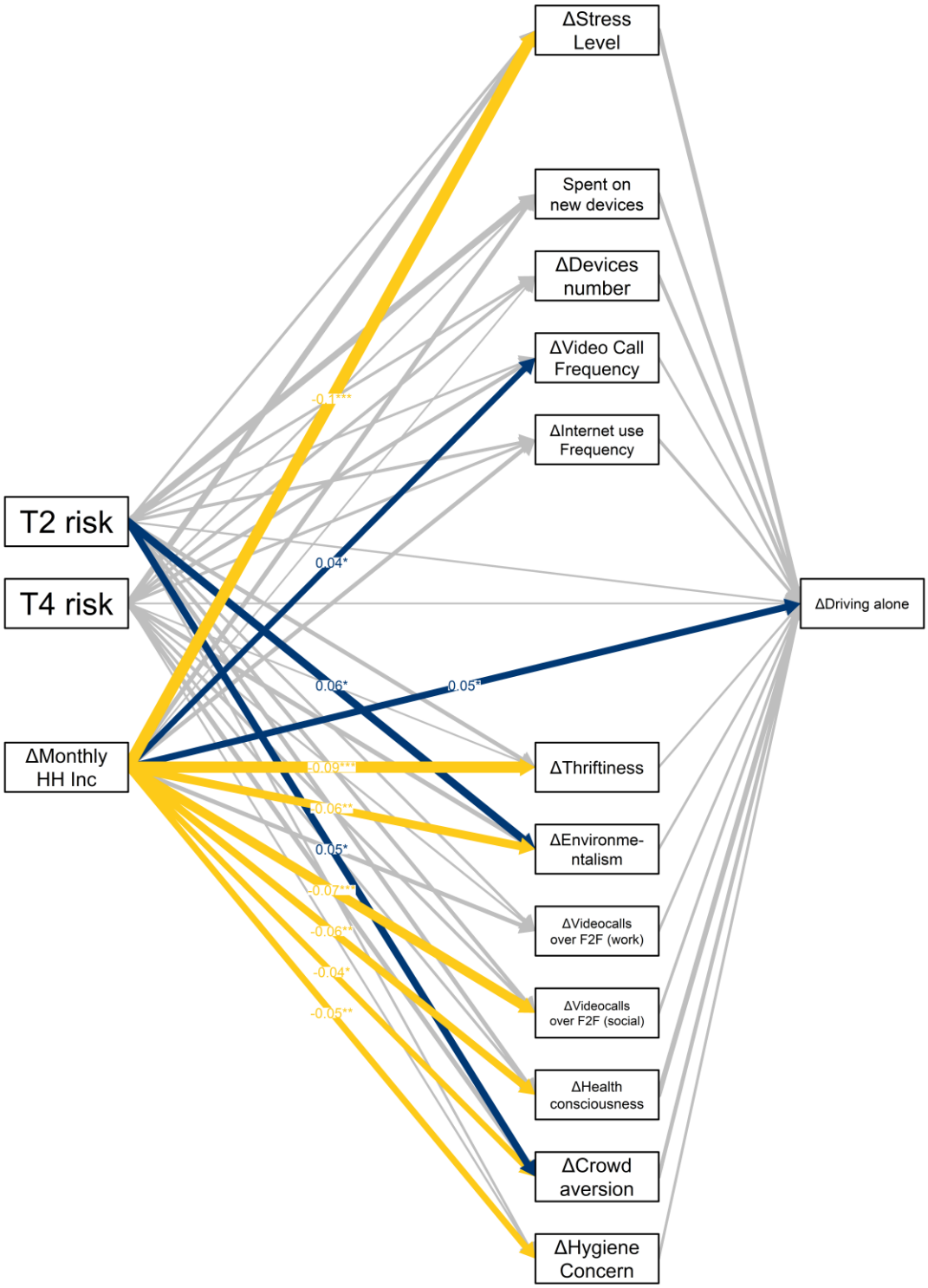
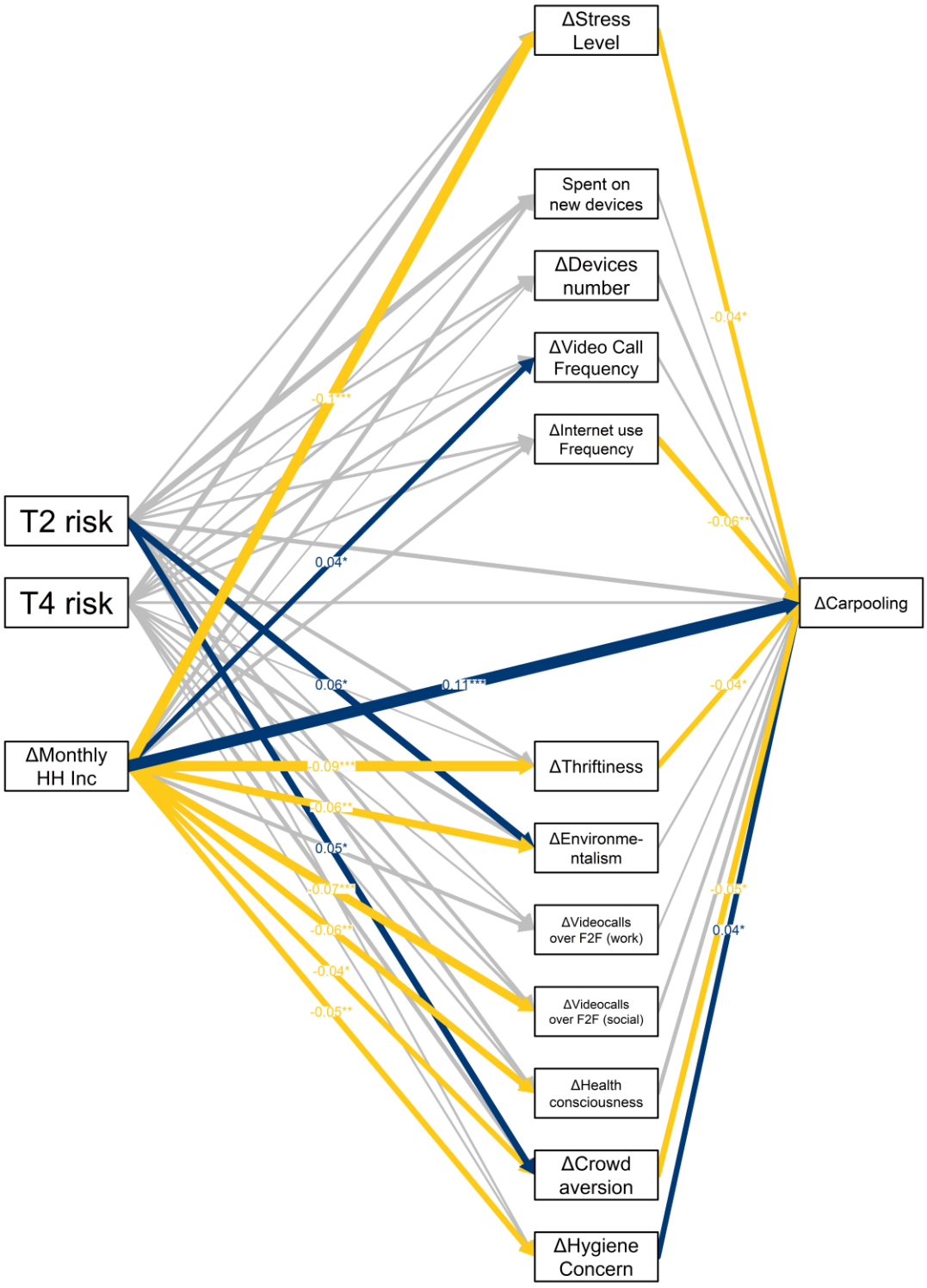


Figure 11. SEM results for daily travel behavior (Note: Blue arrows indicate positive and statistically significant at 95% CI level coefficients, yellow arrows suggest negative and statistically significant at 95% CI level coefficients, and gray arrows represent statistically insignificant coefficients. * indicates p<0.05. ** indicates p<0.01. ***indicates p<0.001.)

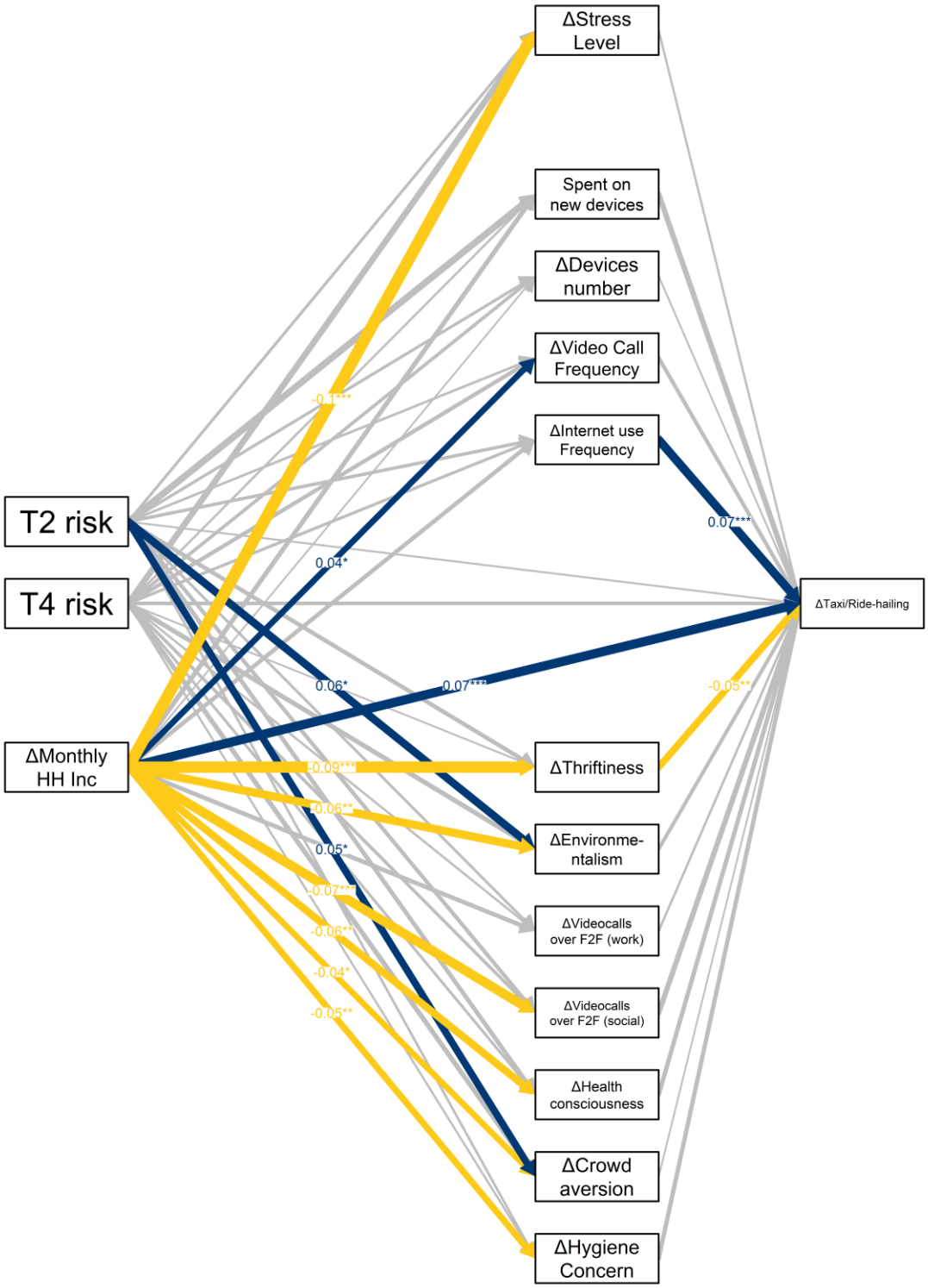
Panel A. Changes in driving alone frequency



Panel B. Changes in carpooling frequency



Panel C. Changes in taxi/ride-hailing frequency



Panel D. Changes in public transport usage frequency

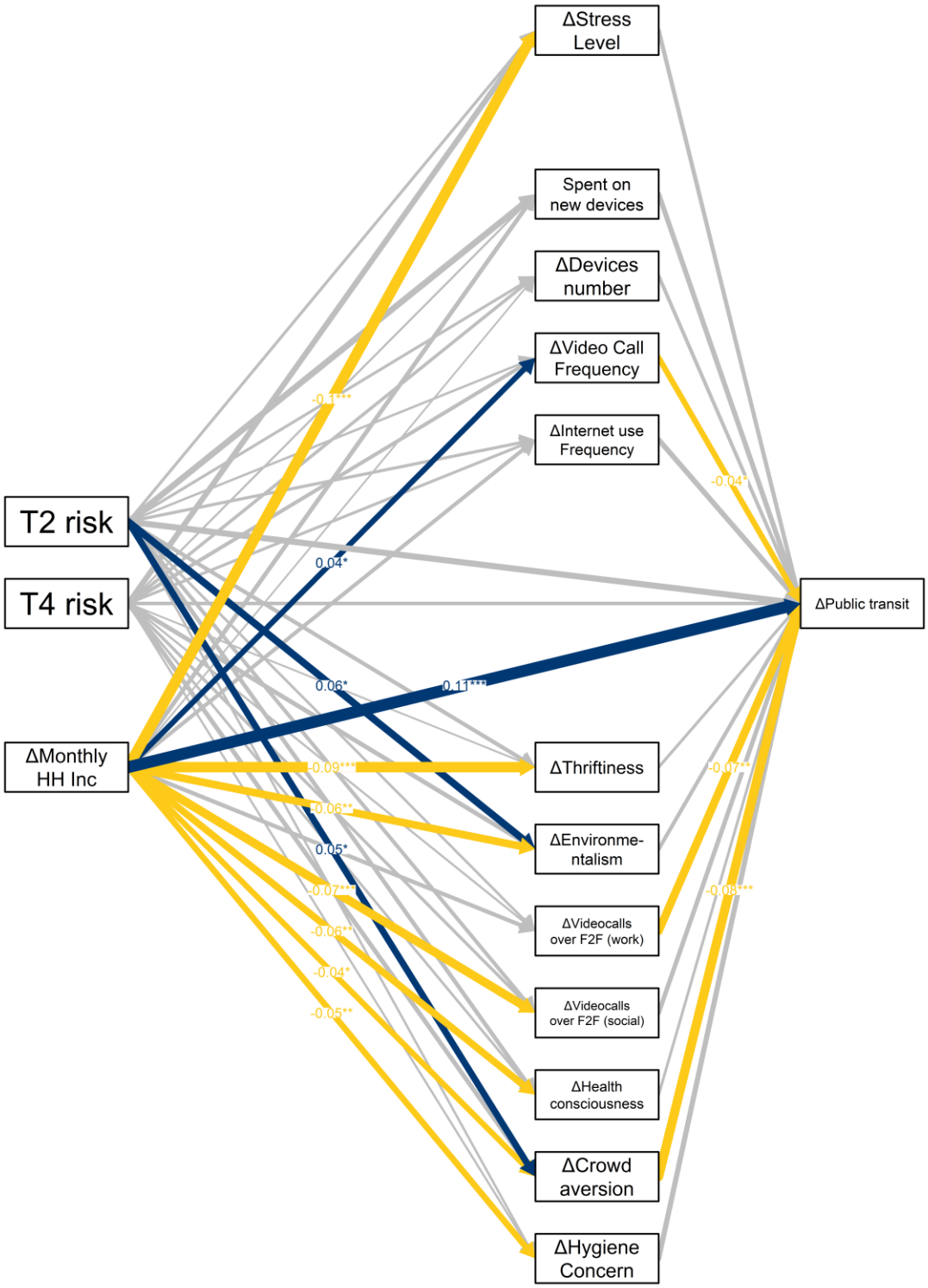
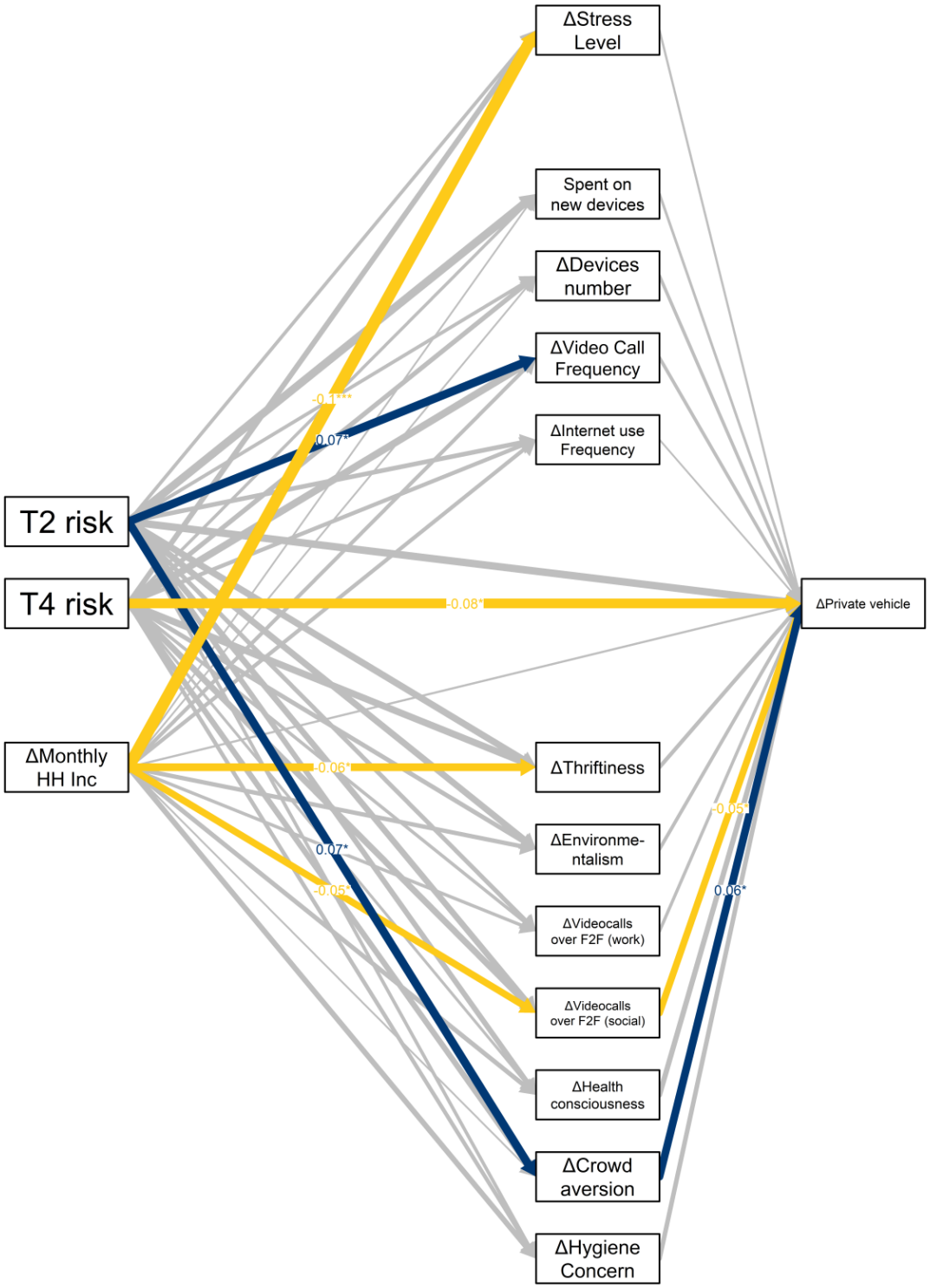
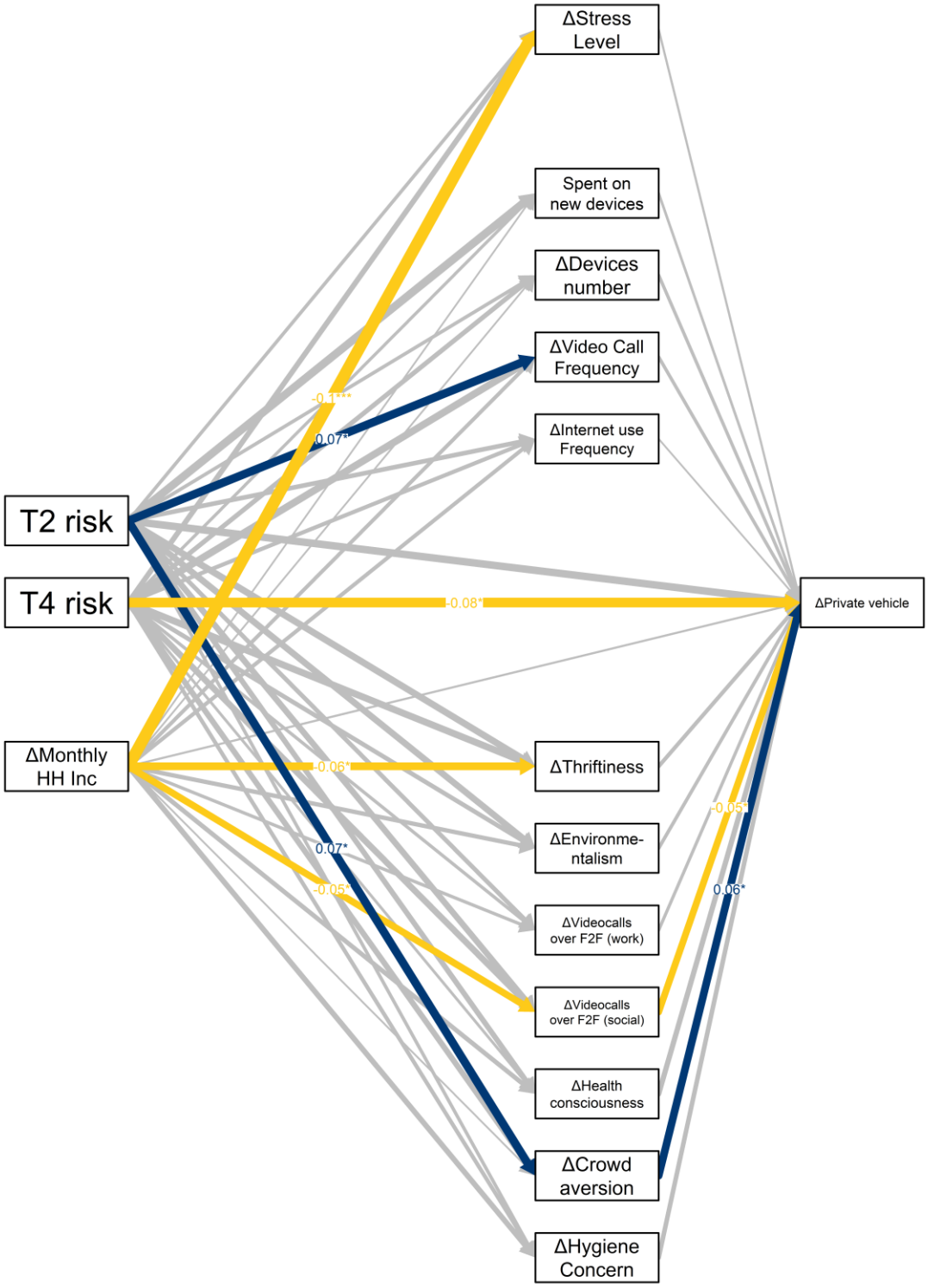


Figure 12. SEM results for commuting mode choices. (Note: Blue arrows indicate positive and statistically significant at 95% CI level coefficients, yellow arrows suggest negative and statistically significant at 95% CI level coefficients, and gray arrows represent statistically insignificant coefficients. * indicates p<0.05. ** indicates p<0.01. ***indicates p<0.001.)

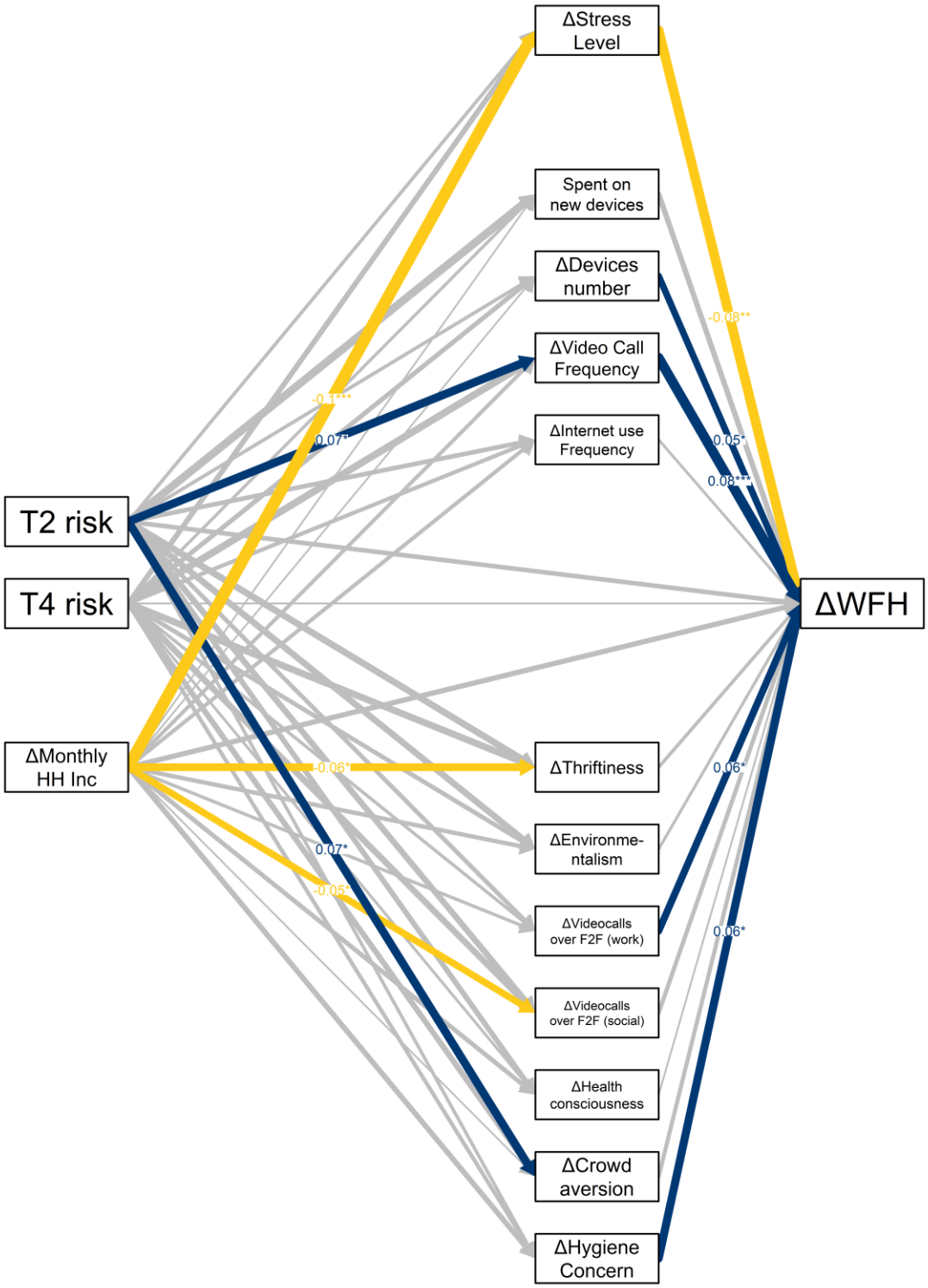
Panel A. Changes in private vehicle usage percentage



Panel B. Changes in public transport usage percentage



Panel C. Changes in working from home percentage



4.3 Forecasting the Persistence of Behavioral Changes

We infer that behavioral changes stemming from different intervening variables have different likelihoods of persisting after the pandemic. First, behavioral changes stemming directly from COVID risks are likely to fade away in the normalization period. After excluding mediation effects of stress and attitudes/values, the direct influence of COVID risks on behavior changes might be due to movement-restricting policies. With the lift of restrictions after the pandemic, such changes could be undone.

Those stemming directly from changes in economic circumstances are likely to last as long as the economic recession does, but are likely to return to normal with an economic recovery. As long as a depressed financial situation persists after the pandemic, so will the associated consumption behavior, but the financial recovery could lead to behavior returning to pre-pandemic patterns. With the rapid re-emergence of new businesses and job opportunities, behavioral changes associated with depressed economic circumstances may already be in reversal (Hale et al., 2021; Guilford & Cambon, 2021).

Those that stem from attitude and value changes are less predictable but are likely to be somewhat persistent and could persist in the long term. Many scholars have discussed the effect of cataclysmic events on attitude and value changes, both in the context of COVID-19 and other events. Some have surmised that COVID-19 will make space, cleanliness and health long-term priorities (Bloom, 2020; Roggeveen & Sethuraman, 2020). History also suggests that changes in attitudes/values due to catastrophes could persist beyond the events. Kennett-Hensel et al. (2012) found that survivors of Hurricane Katrina generally purchased fewer and cheaper things, even after their incomes had returned to normal, due to an awareness of the potential for sudden loss of material possessions.

Those stemming primarily from changes in access to technology and familiarity with technology are likely to persist in the long run, along with the long-term trend of technological improvement. The pandemic has accelerated the development of technology in telecommuting and working from home, forcing people and corporations to invest in infrastructure and technology that enable essential activities to take place online, and to invest the time and effort necessary to learn to use the technology. The infrastructure and skills acquired by employees and companies for remote work, online shopping and other online activities are unlikely to disappear after the pandemic. While some of the restrictions on in-person activities will be lifted, the improvement to the underlying technological infrastructure facilitating online and remote activities will likely enable these behaviors to stay at higher than pre-pandemic levels after the pandemic.

Finally, those stemming primarily from stress are likely to be short-term, fading away as stress induced by the pandemic subsides. Previous studies found that stress effects are expected to be short-term and should wear off with the end of the crisis or possibly

even earlier as people adjust to new circumstances. According to Kennett-Hensel et al. (2012), in the immediate aftermath of Hurricane Katrina, while most survivors became thriftier, a significant number of victims became inclined to purchase luxury items as a way of seeking emotional comfort in the face of stress and uncertainty. However, such an effect was seen mostly in the immediate aftermath of the disaster and eventually wore off. Therefore, behavioral changes associated primarily with stress are likely to return to pre-pandemic states as the pandemic recedes.

Therefore, based on the above arguments, we attempt to make predictions about how the behavior changes would be in the post-pandemic time. The forecast is conservative in the sense that all behavior changes are presumed to disappear unless 1) t-test results from Part 1 suggest a statistically significant difference between behaviors from T1 to T4; 2) the SEM models reveal a strong link between the behavior changes and long-lasting intermediate variables (i.e., technology accessibility, technology familiarity and values/attitudes); and 3) the impacts of technology accessibility, technology familiarity and values/attitudes are consistent in terms of the direction (e.g., most intermediate variables have negative impacts). A significant t-test for the two-period difference is required to show that the behavior changes still exist at T4, otherwise, the changes have elapsed and the behavior pattern at T4 returns back to the T1 level. The consistent SEM results provide stronger evidence for prediction from the perspective of theories.

- *More take-away behavior is likely to persist.*

T-tests from Part 1 show that at T4, the eating out behavior at T4 is still less frequent than at T1, and food pick-up and delivery orders are more frequent at T4 than at T1. As shown in the SEM analysis, the changes in dine-in behavior, take-away behavior, and food delivery behavior are all mainly influenced by attitude/value changes and an increase in familiarity with technology. Yet, the consistent impacts of attitude/value changes and technology familiarity are only observed in takeaway behavior: more videocall usage, higher health consciousness and stronger crowdedness aversion all contribute to more take-away behaviors. Hence, the study predicts that people would still order take-away food more frequently during the normalization period than they did during the pre-pandemic period.

- *Online grocery behavior will become a new norm.*

T-tests from Part 1 show that frequencies of online grocery and online shopping are more frequent at T4 compared with T1, while offline grocery frequency has returned to pre-pandemic level. The SEM model shows that both online grocery and online shopping behaviors are impacted by value changes, particularly technology familiarity. Nonetheless, only online grocery frequency is consistently increased by a stronger crowd aversion, and a higher technology familiarity (i.e., more frequent videocalls and internet usage). For online shopping behavior, as the model shows, an increased thriftiness level persisting into the pandemic might counteract the influence of technology familiarity. Hence, the study predicts that online grocery frequency would remain higher than the pre-pandemic level in the normalization period.

- *Public transit usage for daily travel might stay lower than pre-pandemic levels.*

According to t-test results from Part 1, only change in daily public transit usage is statistically significant, while for other travel modes, the T4 behavior patterns are not substantially different from the ones at T1. The SEM model also shows that a higher level of familiarity with technology, a stronger preference for video calls, and crowd aversion consistently lead to lower public transit usage. Hence, as long as the increase in technology familiarity and attitudes toward crowdedness persist, the public transit frequency is expected to stay slightly lower than the pre-pandemic level.

- *Working-from-home is here to stay.*

According to t-test results from Part 1, almost all changes in commuting mode choices during the pandemic have been neutralized, except for working from home. Based on the SEM model, a higher working-from-home frequency is related to a higher technology accessibility (i.e., number of new devices), technology familiarity (more frequent videocalls), preference for videocalls at work and also a stronger level of hygiene concern. Therefore, working from home practice is likely to stay in the post-pandemic time due to the stickiness of the changing attitude and improved technology infrastructures and reliance.

To summarize, based on the results of t-tests and SEM models, the study predicts that in the normalization periods, there will be a higher rate of take-away and online grocery orders, more frequent working-from-home practices and lower public transit usage for daily travel. It's also worth noting that the magnitudes of changes in travel-related behavior are smaller than the ones in catering and consumption behaviors. It might be attributed to the less elasticity of modal shift and lack of travel mode choices in Hong Kong due to its transit-oriented urban designs.

4.4 Variations in Behavioral Persistence Across Population Segments

In this section, we explore how behavioral persistence differs for different segments of the population. Based on Table 1, we know that the survey sample has a higher income distribution and longer years of education compared to Hong Kong as a whole. Therefore, specifically, we focus on the differences in pandemic-induced behavioral changes among Hong Kong residents of different income brackets and different education levels. At the education level, this study used whether or not they stopped at Higher Secondary (Including Secondary 5 & Sixth Form) as the dividing line to classify the sample into lower and higher education groups. As for the income level, a cut-off line of HK$30,000 per month was used to classify the sample into high-income and low-income groups in order to observe the differences in behavioral changes.

As shown in Table 12a and Table 12b, unsurprisingly, both the high-income and high-education groups have higher proportions of WFH and Online Meetings. However, their behavioral changes in telecommuting also cannot indicate persistence, and both declined sharply after the peak of the fifth wave of the pandemic. In comparison, the higher education group not only has a higher proportion of online meeting behavior than the lower education group, but also has a higher stickiness than the higher income group. On the other hand, the proportion of online meetings used by the lower education groups has almost completely returned to pre-pandemic levels, meaning that they have not been able to benefit from this technology-enabled behavioral shift.

Table. 12a Summary statistics on telecommuting & online meetings with education groups

	Before the pandemic (2019 H2)		First wave pandemic (Feb-Apr 2020)		Fifth wave pandemic (Feb-Apr 2022)		Normalization (Jun-Sep 2022)	
	Lower Education	Higher Education	Lower Education	Higher Education	Lower Education	Higher Education	Lower Education	Higher Education
Working from home *(at least have the option to)*	29.36%	43.68%	37.46%	67.33%	37.71%	72.54%	26.19%	47.15%
Working from home *at least one day a week*	25.69%	29.03%	36.34%	62.10%	36.94%	65.46%	21.56%	32.36%
Working from home *at least three days a week*	11.53%	13.37%	18.45%	35.64%	20.56%	44.66%	11.58%	16.39%
Having Online Meeting *at least one day a week*	17.56%	32.33%	22.82%	55.75%	23.34%	61.71%	18.09%	49.10%
Having Online Meeting *at least three days a week*	6.55%	12.03%	8.17%	24.91%	9.12%	32.41%	6.80%	22.08%

Table. 12b Summary statistics on telecommuting & online meetings with income groups

	Before the pandemic (second half of 2019)		First wave pandemic (Feb-Apr 2020)		Fifth wave pandemic (Feb-Apr 2022)		Normalization (June-Sep 2022)	
	Less than $30,000	Above $30,000	Less than $30,000	Above $30,000	Less than $30,000	Above $30,000	Less than $30,000	Above $30,000
Working From Home *(at least have the option to)*	32.59%	47.41%	46.56%	72.36%	51.20%	75.23%	33.20%	49.78%
Working From Home *at least one day a week*	26.23%	30.20%	45.11%	65.17%	48.03%	67.60%	25.19%	33.70%
Working From Home *at least three days a week*	12.50%	13.10%	23.45%	38.88%	28.60%	48.20%	14.04%	15.87%
Having Online Meeting *at least one day a week*	20.78%	36.33%	31.77%	62.81%	35.45%	68.27%	27.66%	54.02%
Having Online Meeting *at least three days a week*	7.13%	14.37%	11.15%	30.67%	14.90%	38.45%	9.25%	27.50%

In terms of transport mode choice for commuting, the lower education group has a higher proportion of walking (Table 13a), while the higher education group has a higher proportion of private car trips and taxis, but public transport remains the dominant transport mode for both groups. During the pandemic, more people in the high education group shifted from public transport trips to WFH, which corresponds to the previous results. In the comparison between the high- and low-income groups (Table 13b), we can find a great difference between walking and private car between the two groups. However, the modal shift that occurred during the pandemic was still mainly due to the shift from public transport to WFH, and this shift recovered rapidly as the pandemic receded. Therefore, we can conclude that the commuting transport modes of Hong Kong residents before and after the pandemic demonstrated strong stability and did not show significant sustainable behavioral changes.

Table.13a Percentage of respondents using different modes of commuting by education groups

	Before the pandemic (2019 H2)		First wave pandemic (Feb-Apr 2020)		Fifth wave pandemic (Feb-Apr 2022)		Normalization (Jun-Sep 2022)	
	Lower Education	Higher Education	Lower Education	Higher Education	Lower Education	Higher Education	Lower Education	Higher Education
Public transport	73.41%	75.28%	70.13%	64.28%	68.63%	61.67%	71.77%	73.13%
Working from home	2.11%	3.22%	5.82%	13.96%	6.41%	16.93%	2.47%	6.06%
Walking	13.75%	8.37%	13.19%	8.21%	14.07%	7.41%	15.24%	7.54%
Private vehicle	5.99%	9.36%	6.31%	9.76%	6.39%	9.87%	6.20%	9.66%
Taxi/ Ride-hailing	2.08%	3.02%	2.13%	2.74%	2.22%	3.04%	2.02%	2.95%
Bike	1.02%	0.31%	0.85%	0.52%	0.97%	0.23%	0.90%	0.31%
Other means	1.63%	0.44%	1.56%	0.48%	1.31%	0.86%	1.39%	0.74%

Table.13b Percentage of respondents using different modes of commuting by income groups

	Before the pandemic (2019 H2)		First wave pandemic (Feb-Apr 2020)		Fifth wave pandemic (Feb-Apr 2022)		Normalization (Jun-Sep 2022)	
	Less than $30,000	Above $30,000	Less than $30,000	Above $30,000	Less than $30,000	Above $30,000	Less than $30,000	Above $30,000
Public transport	76.62%	71.99%	71.02%	59.50%	67.92%	58.45%	74.12%	70.84%
Working from home	2.66%	3.11%	7.96%	15.94%	10.54%	17.82%	4.56%	5.39%
Walking	12.97%	6.32%	12.45%	6.21%	12.46%	5.53%	13.11%	5.92%
Private vehicle	4.25%	13.69%	4.83%	13.91%	5.19%	13.49%	4.73%	13.57%
Taxi/ Ride-hailing	1.86%	3.86%	2.01%	3.28%	2.37%	3.32%	2.15%	3.31%
Bike	0.64%	0.42%	0.72%	0.50%	0.56%	0.32%	0.45%	0.56%
Other means	1.00%	0.61%	1.00%	0.60%	0.94%	1.07%	0.89%	1.02%

When it comes to the travel modes for destinations other than work, neither the low-income group nor the low-education group changed noticeably in the four periods before, during and after the pandemic (Table 14a and Table 14b). It indicates that even at the peak of the epidemic, when the risk of infection is highest, there is a high proportion of the low-education and low-income groups maintain their transport choices. Against the background of the high expenditure of private car usage and taxi/ ride-hailing in Hong Kong, these groups may be in an unfavorable situation of "having no other choice." In stark contrast, both private vehicle usage and taxi/ride-hailing use increased markedly during the pandemic in the higher-education and higher-income groups. This implies that people tend to make behavioral changes when they have the means to avoid the risk of infection, such as switching from public transport to private vehicle travel and taxis. However, the comparison of the four groups reveals inequalities in the level of transport choices among Hong Kong residents, and the low-income and low-education groups may not have adequate transport options to further avoid the risk of infection during a pandemic.

Table.14a Percentage of respondents using different modes of travel to destinations other than work, by education groups

	Before the pandemic (2019 H2)		First wave pandemic (Feb-Apr 2020)		Fifth wave pandemic (Feb-Apr 2022)		Normalization (Jun-Sep 2022)	
	Lower Education	Higher Education	Lower Education	Higher Education	Lower Education	Higher Education	Lower Education	Higher Education
Public transport	75.07%	74.57%	73.19%	68.47%	74.27%	67.23%	74.03%	71.88%
Walking	12.40%	8.46%	12.93%	10.59%	12.52%	11.07%	12.59%	8.61%
Private vehicle	7.41%	11.72%	7.95%	14.36%	7.69%	14.79%	7.45%	12.82%
Taxi/ Ride-hailing	2.59%	4.27%	2.46%	4.94%	2.21%	4.96%	2.67%	4.76%
Bike	1.05%	0.37%	1.21%	0.58%	1.03%	0.70%	1.04%	0.92%
Other means	1.48%	0.61%	2.26%	1.06%	2.29%	1.25%	2.22%	1.01%

Table.14b Percentage of respondents using different modes of travel to destinations other than work, by income groups

	Before the pandemic (2019 H2)		First wave pandemic (Feb-Apr 2020)		Fifth wave pandemic (Feb-Apr 2022)		Normalization (Jun-Sep 2022)	
	Less than $30,000	Above $30,000	Less than $30,000	Above $30,000	Less than $30,000	Above $30,000	Less than $30,000	Above $30,000
Public transport	78.62%	69.46%	75.42%	62.53%	75.09%	61.96%	77.21%	66.49%
Walking	11.46%	7.46%	12.13%	10.28%	11.98%	10.90%	11.11%	8.28%
Private vehicle	5.63%	16.63%	7.06%	19.46%	7.26%	19.59%	6.09%	17.67%
Taxi/ Ride-hailing	2.41%	5.49%	2.82%	5.94%	2.95%	5.63%	2.93%	5.61%
Bike	0.79%	0.34%	0.93%	0.60%	0.95%	0.61%	1.00%	0.90%
Other means	1.10%	0.62%	1.64%	1.19%	1.77%	1.31%	1.66%	1.05%

Overall, the high-education group has not only a higher proportion of dine-in restaurants, but also a higher proportion of food pick-ups and food deliveries than the low-education group (Table 15a). This implies that the high-education group may have a relatively low proportion of cooking their own meals. Both groups showed a similar persistence in the change in food behavior, with a greater increase in pick-up and food delivery behavior during the normalization period compared to the pre-pandemic period. As shown in Table 15b, the difference in catering-related consumption behaviors between the high- and low-income groups is not substantial in general, with the most notable difference being that the high-income group has a higher proportion of "order food for delivery" since the beginning of the pandemic. The most significant difference is that the high-income group has a higher proportion of "order food for delivery" since the beginning of the pandemic. This difference may be attributed to the relatively high cost of food delivery in Hong Kong.

Table. 15a Catering-related consumer behaviors by education groups

	Before the pandemic (2019 H2)		First wave pandemic (Feb-Apr 2020)		Fifth wave pandemic (Feb-Apr 2022)		Normalization (Jun-Sep 2022)	
	Lower Education	Higher Education	Lower Education	Higher Education	Lower Education	Higher Education	Lower Education	Higher Education
Dine-in *at least once a week*	84.30%	90.82%	64.14%	62.88%	56.03%	56.13%	76.37%	82.93%
Dine-in *at least three times a week*	52.74%	62.88%	28.27%	28.53%	22.87%	23.18%	37.38%	44.68%
Order food for pick-up *at least once a week*	56.37%	51.65%	64.39%	69.96%	64.98%	74.66%	66.16%	72.99%
Order food for pick-up *at least three times a week*	22.03%	17.67%	31.14%	36.84%	35.44%	43.98%	30.13%	34.58%
Order food for delivery *from a restaurant at least once a week*	29.62%	30.69%	35.11%	44.35%	35.70%	47.92%	34.94%	43.44%
Order food for delivery *from a restaurant at least three times a week*	8.69%	9.24%	13.50%	19.61%	15.27%	22.91%	12.49%	15.67%

Table. 15b Catering-related consumer behaviors by income groups

	Before the pandemic (2019 H2)		First wave pandemic (Feb-Apr 2020)		Fifth wave pandemic (Feb-Apr 2022)		Normalization (Jun-Sep 2022)	
	Less than $30,000	Above $30,000	Less than $30,000	Above $30,000	Less than $30,000	Above $30,000	Less than $30,000	Above $30,000
Dine-in *at least once a week*	89.51%	92.19%	67.09%	65.21%	59.75%	57.80%	82.61%	85.76%
Dine-in *at least three times a week*	59.24%	65.29%	31.97%	29.84%	26.53%	24.74%	44.43%	47.98%
Order food for pick-up *at least once a week*	57.71%	51.52%	71.36%	71.20%	75.09%	76.42%	73.91%	74.55%
Order food for pick-up *at least three times a week*	22.84%	17.25%	38.36%	37.21%	45.31%	46.24%	36.00%	35.65%
Order food for delivery *from a restaurant at least once a week*	30.67%	32.75%	40.66%	46.66%	45.31%	50.52%	42.00%	46.75%
Order food for delivery *from a restaurant at least three times a week*	9.93%	10.30%	18.58%	19.35%	21.12%	25.90%	15.91%	17.26%

In terms of changes in shopping behavior, both the high- and low-income groups, as well as the high and low-education groups, show a change in the increase of online shopping behavior, and this change demonstrates a strong stickiness. Specifically, the high-education group has a higher proportion of online purchases compared to the low-education group. This difference also exists between the high- and low-income groups, but the magnitude is much smaller. Despite the differences in proportions, these results suggest that changes in online shopping behavior are sustainable, meaning that online shopping will likely become the new normal of shopping behavior in Hong Kong.

Table. 16a Retailing-related consumer behaviors by education groups

	Before the pandemic (2019 H2)		First wave pandemic (Feb-Apr 2020)		Fifth wave pandemic (Feb-Apr 2022)		Normalization (Jun-Sep 2022)	
	Lower Education	Higher Education	Lower Education	Higher Education	Lower Education	Higher Education	Lower Education	Higher Education
Shop for groceries in a store *at least once a week*	91.39%	90.87%	88.78%	87.52%	86.24%	85.79%	90.38%	92.06%
Shop for groceries in a store *at least three times a week*	52.15%	48.24%	42.28%	39.49%	40.34%	39.71%	49.96%	46.57%
Order groceries online for delivery *at least once a week*	33.76%	39.44%	41.18%	52.94%	44.30%	57.05%	43.29%	54.35%
Order groceries online for delivery *at least three times a week*	8.78%	10.26%	13.33%	20.26%	16.37%	23.99%	14.26%	20.58%
Order other items online for delivery *at least once a week*	35.61%	45.98%	40.93%	54.19%	42.78%	56.19%	44.30%	56.51%
Order other items online for delivery *at least three times a week*	8.61%	11.13%	11.05%	16.53%	12.83%	19.56%	12.91%	17.88%

Table. 16b Retailing-related consumer behaviors by income groups

	Before the pandemic (2019 H2)		First wave pandemic (Feb-Apr 2020)		Fifth wave pandemic (Feb-Apr 2022)		Normalization (Jun-Sep 2022)	
	Less than $30,000	Above $30,000	Less than $30,000	Above $30,000	Less than $30,000	Above $30,000	Less than $30,000	Above $30,000
Shop for groceries in a store *at least once a week*	91.85%	91.11%	90.11%	88.02%	87.91%	87.40%	91.65%	92.60%
Shop for groceries in a store *at least three times a week*	50.52%	44.25%	45.78%	35.71%	42.87%	39.54%	47.65%	43.95%
Order groceries online for delivery *at least once a week*	38.34%	41.32%	48.42%	56.22%	53.16%	60.12%	50.43%	58.18%
Order groceries online for delivery *at least three times a week*	9.93%	9.65%	17.48%	20.51%	21.93%	24.51%	17.30%	22.09%
Order other items online for delivery *at least once a week*	43.91%	45.55%	50.55%	53.92%	53.79%	57.80%	54.26%	57.96%
Order other items online for delivery *at least three times a week*	10.41%	9.76%	14.75%	15.09%	18.23%	18.61%	15.04%	17.60%

V. CONCLUSIONS & POLICY RECOMMENDATIONS

5.1 Consolidated Recapitulation of Core Outcomes for the Four Objectives

Objective 1: Descriptive Results of Behavioral Change

Leveraging the empirical data collected in the demographically representative survey, this study first sheds light on the profound impact of the COVID-19 pandemic on the daily behavior, mental health, and values of Hong Kong residents. The pandemic has forced people to adapt to new rules and circumstances, resulting in significant shifts in their behavior. While some of these changes may be temporary, others are likely to become the new norm in the post-pandemic era. More importantly, the changing patterns of behavior among Hong Kong residents depicted in this study reflect the features of Hong Kong as a typical high-density metropolis, in contrast to the changes that occurred in other regions.

As an international business center, financial center and higher education hub, Hong Kong unsurprisingly holds a strong stickiness for the use of online meetings. However, as an ultra-high-density metropolis, Hong Kong's soaring housing prices limit the amount of living space available to residents. Potentially due to the constraints of the living environment (especially living space), this study finds that the prevalence of telecommuting cannot persist in Hong Kong post-pandemic. Along with the demise of telecommuting in the post-pandemic era, public transport is likely to remain the dominant mode of commuting for Hong Kong residents. Interestingly, modes of transport that have proven to be of more importance elsewhere amid the pandemic, such as private vehicles, walking and cycling, cannot feature more prominently in the commuting choices of Hong Kong residents. This is a reflection of the excellence and efficiency of Hong Kong's public transport system. However, when the purpose of trips is no longer commuting, people's reliance on public transport decreases in the period of normalization, while the rest of the transport modes have a small increase, which can be partially explained by people's preference to avoid crowds since the pandemic.

Hong Kong's distinctive characters as a high-density metropolis are also reflected in the changes in catering-related consumption patterns. Since the pandemic, the decline in restaurant dine-in behavior has been primarily replaced by food pick-up at restaurants, which is significantly higher than the increase in food delivery. The distance from work or from home to restaurants is relatively short for Hong Kong residents, thanks to its high-density design, indicating food pick-up is a no more time-consuming act, compared with food delivery. In addition, the high labor costs in Hong Kong contribute to the expensiveness of food delivery service, which further makes it an inferior option. The remaining strong willingness to pick-up in-store also demonstrates the better recovery prospects for catering establishments as they continue to engage directly with customers.

The study also suggests that while Hong Kong people maintain their habit of buying groceries in physical shops, they are increasingly accepting online shopping as an alternative shopping option, indicating that consumers have more choices to compare different items or different prices for the same items. Unfortunately, from this study, we cannot learn the proportion of amounts spent by Hong Kong residents on different shopping options and therefore cannot further describe the shopping patterns of Hong Kong people. Moreover, by combining the consumption patterns of dining and shopping, the study shows that the delivery and takeaway sectors will become an important part of the Hong Kong economy.

Other findings for objective 1 include that: 1) Hong Kong residents have developed a more modest view of consumption after the worst of the fifth wave of the pandemic, with a greater agreement to 'Don't like to buy things more than I need'; 2) since the outbreak of the pandemic, Hong Kong people have become more conscious of environmental hygiene, more conscious of their own health and more averse to crowding, and these changes in values are highly sticky; 3) high-frequency internet browsing with PC and high-frequency social media use behavior rose and persisted since the pandemic; 4)the popularity of digital payments is continuing, demonstrating a prosperous trend of greater importance in the future; and 5) last but not least, the dismal post-pandemic psychological stress status of the Hong Kong population should be given high priority, in contrast to the strong resilience in other regions.

Objective 2: Factors Mediating the Behavioral Changes

The first task is primarily descriptive and gives tentative explanations for the changes in daily behavior and their recovery. Therefore, more rigorous proof and attribution of changes are supplemented in our second task. Leveraging the SEM model, we investigate the reasons behind COVID-19-induced behavioral changes during and immediately after the pandemic. Specifically, how do various intervening variables mediate the behavioral impacts of COVID-19? This study underscores the complex interplay between economic, technological, attitudinal, and stress-related factors in shaping behavioral responses to the COVID-19 pandemic. Each of these mediating variables contributes to a nuanced understanding of how people adjusted their behaviors in response to the health crisis and its associated impacts.

Economic circumstances significantly mediate the effects of COVID-19 on behavior. This study highlights that changes in monthly household income directly impact most behaviors. A decrease in income is associated with a reduction in dining in, taking away, food delivery, and various travel behaviors. This suggests that economic strain during the pandemic directly discourages activities that incur additional expenses. Additionally, economic conditions influence stress levels, with decreased income correlating with increased stress, which further affects behavior related to crowded places and work environments.

Second, changes in technology accessibility likely facilitated shifts towards online activities. For instance, increased online shopping and food delivery can be attributed to greater access or reliance on technology during the pandemic. Similarly, the preference for video calls over face-to-face communication for social and professional purposes implies a shift towards digital platforms, potentially mediated by the availability and accessibility of these technologies.

Moreover, attitudes and values serve as significant mediators in behavioral changes during COVID-19. We indicate that environmental awareness and aversion to crowdedness are particularly influential. For example, increased neighborhood risk levels enhance environmentalism and crowdedness aversion, which in turn encourage physical grocery shopping and discourage dining out or using public transport. Additionally, economic downturns prompt a rise in thriftiness, leading to a general decrease in consumption and travel behaviors. The shift in preference towards video calls over in-person interactions for social reasons also reflects a change in social attitudes, further affecting dining frequencies.

In addition, the stress level during the pandemic is another important mediator, particularly concerning economic situations. Higher stress levels, associated with decreased household income, deter visits to crowded places and reduce the likelihood of working from home. This stress response may be due to crowded living conditions or lack of appropriate home offices, which are less tolerable for individuals experiencing increased stress. Thus, stress mediates behavior by influencing preferences for work location and social activities, with higher stress prompting avoidance of crowded environments and reducing the growth of certain travel behaviors.

Objective 3: Forecasting the Persistence of Behavioral Changes

Based on patterns of behavioral changes during and immediately after the pandemic and analysis of the intervening variables involved in these changes, we then use our model built in task 2 to predict the extent to which different COVID-19-induced behavioral changes are likely to persist into the future.

There is a likelihood of increased take-away food orders persisting post-pandemic. The study found that even after normalization, the frequency of eating out has not returned to pre-pandemic levels, while food pick-up and delivery orders have increased. This change is primarily influenced by attitude/value changes and increased technology familiarity, with the consistent impact observed on take-away behavior being due to more video call usage, higher health consciousness, and a stronger aversion to crowdedness.

This study also predicts that online grocery shopping will become a new norm. T-tests indicate that online grocery shopping remains more frequent post-pandemic compared

to pre-pandemic levels, while offline grocery shopping has returned to pre-pandemic frequencies. The SEM model suggests this behavior is influenced by changes in values and an increase in technology familiarity, with a consistent increase associated with a stronger crowd aversion and higher technology familiarity.

Daily public transit usage might stay lower than pre-pandemic levels. T-test results show a statistically significant change in public transit usage, with a consistent decrease linked to higher technology familiarity, a preference for video calls, and crowd aversion. This suggests a long-term shift in the use of public transport.

Last but not least, the practice of working from home (WFH) is expected to continue post-pandemic. Almost all changes in commuting modes have reverted to pre-pandemic patterns except for WFH. The SEM model relates higher WFH frequency to increased technology accessibility, familiarity, a preference for video calls at work, and stronger hygiene concerns. The acquired infrastructure and skills for remote work are anticipated to support the persistence of this behavior.

Objective 4: Variations in Behavioral Persistence Across Population Segments

Task 4 uncovers the differences in behavioral changes' persistence among Hong Kong residents of different income brackets and different education levels. In terms of telecommuting and online meeting behaviors, we find that both High-Income and High-Education segments exhibited higher proportions of WFH and online meeting behaviors, while the High-Education group showed more stickiness in online meeting behaviors compared to the High-Income group. On the other hand, the adoption of online meetings for low-education groups returns almost to pre-pandemic levels, suggesting a lack of persistence and potential barriers to benefiting from this technological shift.

When it comes to transport mode choices for commuting, we find a stark difference between walking and private car usage, with income being a significant factor. Moreover, the Low-Education Group shows a higher proportion of walking, which could correlate with fewer resources to opt for private transport modes. As for transport mode choices for destinations other than the workplace, we find that the Low-Income and the Low-Education Groups have strong persistence in transport choices, which suggests limited options and a potential lack of access to safer, private transport during the pandemic's peak. In stark contrast, there have been marked increases in private vehicles and taxi/ride-hailing use during the pandemic for high-education and high-income groups.

This study also finds that the High-Education Group has higher proportions of dining out, food pickups, and food deliveries compared to the low-education group, possibly indicating a lower proportion of home-cooked meals. In terms of changes in shopping behavior, both the high- and low-income groups, as well as the high and low-education

groups, show a change in the increase of online shopping behavior, and this change demonstrates a strong stickiness.

5.2 Policy Implications and Recommendations

Based on the abundant research findings presented in the study, it is imperative for the Hong Kong Government to consider a suite of policy recommendations to address the evolving needs of its citizens and the economy in the post-pandemic landscape. The study highlights several behavioral changes among the residents that have the potential to shape future policy directions.

- *Optimizing the configuration of urban spaces and enhancing digital infrastructure to accommodate the growing demand for telecommuting*

The widespread use of digital technology in work and business has been one of the most significant shifts. As an international business and financial center, Hong Kong's reliance on online meetings has increased significantly, driven by the epidemic. However, small living spaces may hinder the continued growth of telecommuting in Hong Kong. While Hong Kong's current industry model still relies heavily on face-to-face work, our research suggests that highly educated and high-income individuals are more likely to work remotely. This means that as Hong Kong continues to grow, the demand for teleworking will gradually increase.

Hong Kong intends to make the northern metropolitan area the second center of its economy and to use technology and innovation as the second engine of economic growth. The need for teleworking has thus become more pressing: on the one hand, STI talents, especially those in the information and communication technology (ICT) field, will prefer environments with telecommuting options; on the other hand, the distance between the northern metro area and the old center will objectively increase the need for telecommuting. Therefore, the Hong Kong Government must seriously consider how to adapt to future teleworking patterns.

First, the reconfiguration of urban space needs to be considered. Although every teleworker dreams of having a comfortable environment to work from home, the realization of this goal requires the joint efforts of developers and other parties, and is more of a market behavior that is difficult for the government to directly influence. However, the government can meet the demand by setting up public telecommuting spaces around existing residential areas with strong demand for telecommuting; at the same time, it can reserve corresponding space in the future residential planning for the northern metropolitan area.

Second, digital infrastructure needs to be strengthened. Enhancing network bandwidth and coverage is a top priority. While Hong Kong, as a highly developed city, already has a good network infrastructure, there is a need to further extend the coverage of high-speed broadband networks, especially to ensure that remote areas can also enjoy high-

quality Internet services. In addition, accelerating the full deployment of 5G networks will provide higher bandwidth and lower latency for telecommuting, supporting high-quality video conferencing and large file transfers. On telecommuting tools, Hong Kong should support local technology companies in developing collaboration software suitable for the local market, and provide training and support to help enterprises and employees familiarize themselves with and make efficient use of existing telecommuting tools, such as video conferencing software and project management platforms.

It must be recognized that home-based work tends to apply mainly to those who are in a more privileged position in society. Vulnerable groups in the workforce, including low-skilled manual workers, casual laborers in food delivery and ride hailing services, and domestic workers, rely on interpersonal contact, commuting, or frequent travel for their livelihoods, thus exposing them to practical barriers and higher health risks. If teleworking develops into a more permanent arrangement, it has the potential to lead to new forms of deprivation and socio-economic inequality.

Therefore, while promoting teleworking, the Hong Kong Government must ensure that its policy is inclusive and takes into account the needs and challenges of all social groups. Only in this way can social equity and harmony be achieved while promoting economic development.

- *Ensuring the safety and attractiveness of public transportation during future pandemics, especially to protect the health and safety of low-income groups*

Studies have shown that despite the global preference for the use of private cars during a pandemic, public transportation remains the main mode of commuting for Hong Kong residents, especially for low-income groups. It is therefore necessary for the Hong Kong government to further invest in the public transportation system to ensure its attractiveness and efficiency. Even during the worst period of the pandemic in Hong Kong, low-education and low-income groups were not able to enjoy low infection risk modes of transportation such as private cars and had to rely on public transportation. Therefore, should we face another pandemic in the future, the Government should be committed to maintaining a high standard of hygiene to protect the health and safety of residents who choose public transportation as their main mode of travel.

To reduce the risk of infection in public transportation, the Hong Kong government can adopt a series of innovative measures to protect the health of residents. First, it is crucial to enhance the frequency of cleaning and disinfection of public transport. Public transport modes in Hong Kong, such as the MTR and buses, should be cleaned more frequently during peak hours, with particular focus on disinfecting high-touch surfaces such as handrails, seats and door handles. In addition, the use of ultraviolet disinfection equipment and antimicrobial coating technology can be effective in inhibiting the spread of germs on a sustainable basis. Secondly, upgrading the ventilation system is key. High-efficiency air filtration and purification systems can be installed in the MTR

and buses in Hong Kong to ensure air circulation and minimize the spread of viruses in the air. At the same time, air quality monitoring systems are installed to detect and regulate the quality of air inside the vehicles in real time to safeguard the health of passengers.

The promotion of contactless technology can also significantly reduce the risk of infection. The Government should encourage the popularization of contactless payment systems to reduce cash transactions and the use of physical tickets. Passenger density management is another area to focus on. Using cell phone applications and electronic displays, real-time display of the degree of crowding in carriages and on platforms can be used to guide passengers to travel in a staggered manner or to choose a more spare train. Adjusting the frequency and number of vehicles in real time according to passenger flow to avoid overcrowding during peak hours is an effective measure to alleviate passenger density. Finally, health monitoring and information dissemination also need to be strengthened. The installation of temperature detection devices at important transportation hubs and station entrances can help screen passengers with fever and prevent potential sources of infection from entering the public transport system.

Through these measures, the Hong Kong government can effectively reduce the risk of infection in public transportation and ensure that the population can still safely rely on public transportation in the event of a possible future pandemic.

- *Supporting Diverse Transportation Needs Amid Changing Travel Preferences*

The study also shows that while reliance on public transportation for non-commuting trips has declined, the use of other modes of transportation has increased. This suggests that the government should adapt to residents' more diverse transportation choices to meet their preferences while promoting sustainable urban transportation patterns.

First the government needs to improve walking and cycling infrastructure, with cycling-related infrastructure being the most in short supply. The Hong Kong government should build more dedicated bicycle lanes and ensure that these are separated from motorized vehicles and well-maintained to provide a safe and level surface. In addition, the government can install additional secure bicycle parking facilities at key locations such as MTR stations, bus stops, commercial and residential areas to encourage more people to choose cycling.

In addition, the Hong Kong government needs to further resolve the legal disputes over uber and Hong Kong cab related issues rather than letting them fall into a gray area. On this premise, the Hong Kong government needs to ensure the safety and convenience of cab and ride hailing services. Specifically, it can encourage and promote electronic and contactless payment methods to reduce cash transactions and enhance the safety and convenience of transactions. Hong Kong cabs can also adopt a dynamic pricing mechanism, adjusting prices according to supply and demand, to ensure that there are

sufficient vehicles to serve even during peak hours and in remote areas.

- *Fostering Seamless Pick-up Services, and Promoting Digital Literacy to Bridge the Consumption Gap in Online Shopping*

In terms of consumption patterns, the observed shift from dine-in to food pick-up services should prompt the government to facilitate the necessary urban planning adjustments. Given the high-density nature of Hong Kong and its efficient design, policies that enable seamless pick-up services, such as improved parking and dedicated pick-up zones, could significantly benefit restaurants and consumers alike. Moreover, the increased acceptance of online shopping as an alternative to physical store visits suggests that the government could further promote digital literacy, particularly among lower-income communities, to ensure equitable access to this new consumption mode.

Moreover, the significant impact of the pandemic on the retail and food service sectors necessitates government support to facilitate their adaptation to new norms, such as the transition to digital payments and the enhancement of food pick-up service infrastructures. Such support could expedite the recovery of these sectors and align them with the changing consumer behaviors.

- *Prioritizing Mental Health in Policy Making Post-Pandemic*

The research delineates the profound psychological ramifications of the pandemic on the populace of Hong Kong, revealing a pervasive escalation in stress levels. Unlike other regions where there is a marked rebound in mental health post-pandemic, the evidence suggests that the augmented stress experienced by Hong Kong's residents may endure. It is paramount for the government to place mental health at the forefront of its policy agenda, by enhancing mental health services and introducing initiatives aimed at mitigating stress and fostering community resilience. A focus on mental well-being is essential for the recovery and productivity of society.

- *Financial Support for Economic Resilience Among Vulnerable Groups*

Lastly, the nuanced understanding of the interplay between economic, technological, attitudinal, and stress-related factors in shaping behavioral responses to COVID-19 has also highlighted the need for economic resilience. The government should consider establishing financial support mechanisms that target low-income households most susceptible to economic fluctuations. Such measures could alleviate stress and stabilize consumption patterns, thereby contributing to the overall economic health of the city.

In conclusion, the Hong Kong Government must consider these recommendations with a view to fostering a resilient, adaptive, and sustainable urban environment that caters to the post-pandemic behavior of its residents. The policies should be proactive, forward-thinking, and inclusive, ensuring that the city not only recovers from the pandemic but also emerges stronger and more prepared for future challenges.

VI. PUBLIC DISSEMINATION

Presented research at the 3rd International Workshop on Public Policy June 28-30, 2022 at Budapest. The research, titled "The Impact of Changing Work Arrangements on the Fiscal Base of Urban Government: Prospects for Adaptation and Mitigation," was recently accepted for publication at the International Review of Public Policy.

Present our research work in the Seminar on Post-pandemic Energy Use Behaviors that will take place at the International Institute for Applied Systems Analysis (IIASA) on March 6-8, 2024. The seminar aims to promote the academic community's understanding of people's energy use behaviors in the building and transportation sectors, particularly after the COVID-19 pandemic.

Additionally, we will make the final version of our report publicly accessible by hosting it on the Division of Public Policy's official website, specifically within the case library section. This will ensure that a wide audience, particularly public and government units, can easily access and review our research findings.

We will publish the report on the website of the Center for Applied Economic, Social, and Environmental Research (CAESER). As a multidisciplinary research platform, CAESER's website enjoys significant traffic and influence, which will help further extend the reach and impact of our report.

Moreover, we will integrate our research findings into the course materials for the HKUST Leadership and Public Policy Programs. By embedding our research into educational resources, we can train future policymakers and ensure that our findings are fully utilized and disseminated within the educational community.

Furthermore, we commit to actively presenting and disseminating the research outcomes at every suitable opportunity in the future, targeting both public audiences and government units. This includes, but is not limited to, seminars, forums, and policy advisory meetings.

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