# The relationships between:
# (1) Individual's travel patterns,
# (2) activities (time use), and
# (3) their health indicators
(in a tropical developing countries)

Yusak O. Susilo
KTH Royal Institute of Technology

Acknowledgement:
Chengxi Liu (VTI the Swedish National Road and Transport Research Institute)
Dimas Dharmowijoyo (University of Technology Petronas, Malaysia)

# Outline

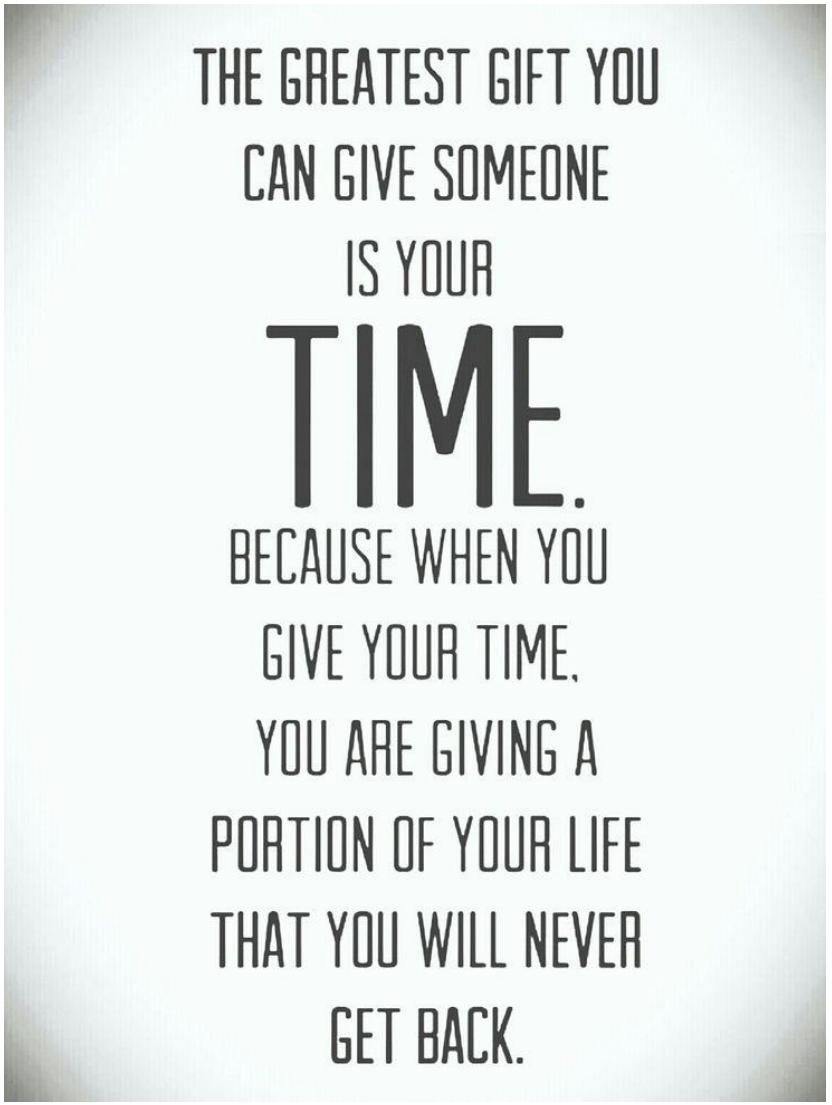
- Importance of time
- How time is distributed over 24 hours
- Who is more immobile than others, and how this different accros different socio-demographic groups
- How these relate to one’s physical, mental, and social health indicators

**EU working hours**

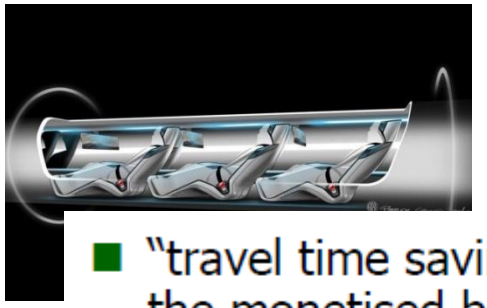
Click heading to sort table. Download this data

| Country | All in employment | Full-time employment | Productivity index per hour worked (EU=100) |
|---|---|---|---|
| **EU** | **37.4** | **41.6** | **100** |
| Austria | 37.8 | 43.7 | 115 |
| Belgium | 36.9 | 41.7 | 134.7 |
| Bulgaria | 40.9 | 41.3 | 41.7 |
| Cyprus | 40 | 42.1 | 80 |
| Czech Republic | 41.2 | 42.3 | 70.1 |
| Denmark | 33.8 | 39.1 | 119.2 |
| Estonia | 38.6 | 40.8 | 61.1 |
| Finland | 37.4 | 40.3 | 111.3 |
| France | 38 | 41.1 | 132.7 |
| Germany | 35.6 | 42 | 123.7 |
| Greece | 42.2 | 43.7 | 76.3 |
| Hungary | 39.4 | 40.6 | 59.2 |
| Ireland | 35 | 39.7 | 125.6 |
| Italy | 37.6 | 40.5 | 101.5 |
| Latvia | 39.2 | 40.8 | 47.1 |
| Lithuania | 38.3 | 39.7 | 55.7 |
| Luxembourg | 37 | 40.5 | 189.2 |
| Malta | 38.8 | 41.4 | 81.9 |
| Netherlands | 30.5 | 40.9 | 136.5 |
| Poland | 40.6 | 42.2 | 53.9 |
| Portugal | 39.1 | 42.3 | 65.4 |
| Romania | 40.5 | 41 | 41.7 |
| Slovakia | 40.5 | 41.5 | 78.4 |
| Slovenia | 39.6 | 41.8 | 80.2 |
| Spain | 38.4 | 41.6 | 107.9 |
| Sweden | 36.5 | 40.9 | 115.5 |
| **UK** | **36.3** | **42.7** | **107.2** |

SOURCE: ONS

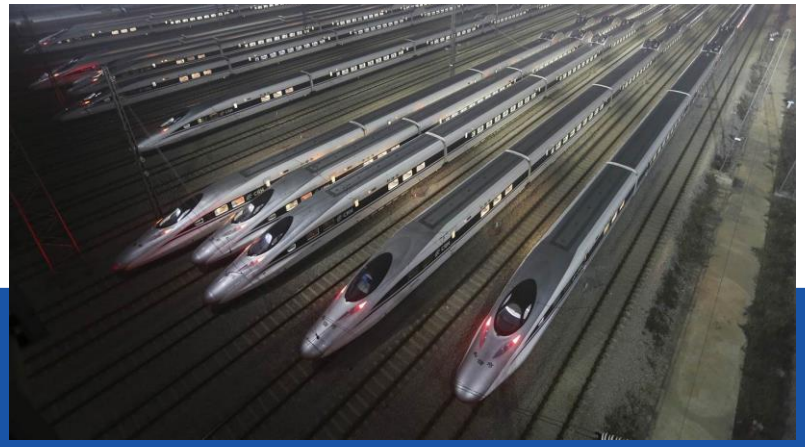


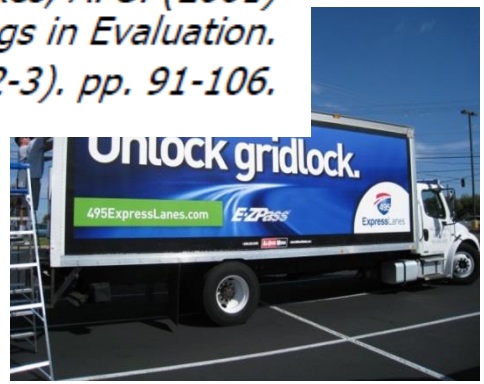
# Time Saving …



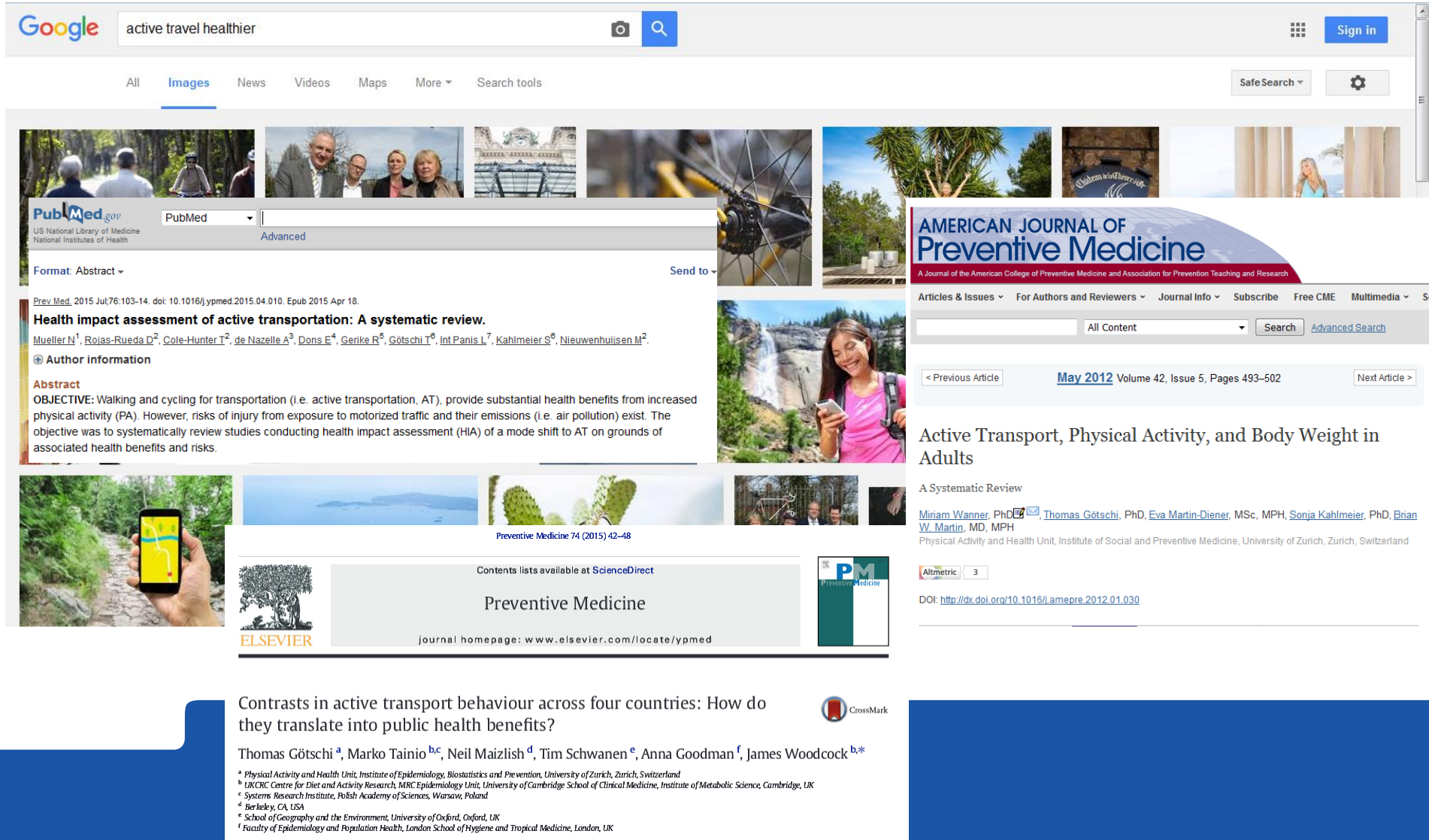
- "travel time savings have accounted for around 80% of the monetised benefits within the cost-benefit analysis of major road schemes"

*Mackie, P. J., Jara-Diaz, S. &Fowkes, A. S. (2001) The Value of Travel Time Savings in Evaluation. Transportation Research E. 37(2-3). pp. 91-106.*



# Healthy = AT + time ?



# Research need and objectives

It is important to take into account the benefits that an individual gains from both physically activity travel and their day-to-day in-home and out-of-home activities in order to better understand the real value of physically active travel behaviours; not only to physical health, but also to individual's social and mental health.

This study investigates the relationships between travellers' physically active travel with the type and intensity of their daily activities and their physical, mental and social health conditions

(+ most of the previous studies focused on developed countries' cases – in this study we use data from Indonesia)

# Study area and data


732 individuals and 191 households for 21 consecutive days.

Contains household, physical activity and lifestyle, individual's subjective characteristics, time-use and activity diary, and subjective well-being data.

Focus: Time use diary, twenty-three in-home and out-of-home activity classifications, travel duration and mode characteristics, and multitasking activities for adults, young adults and children above 7 years old.

Dharmowijoyo, D.B.E., Susilo, Y.O., Karlström, A., and Adiredja, L.S. (2015) Incorporating Three-weeks' Household Time-use and Activity Diary with Individual Attitudes, Physical Activities and Psychological Characteristics in the Bandung Metropolitan Area. *Transportation Research part A*, Vol. 80, pp. 231-246.

# Before we talk about health elements: Why time-use and not travel diary?

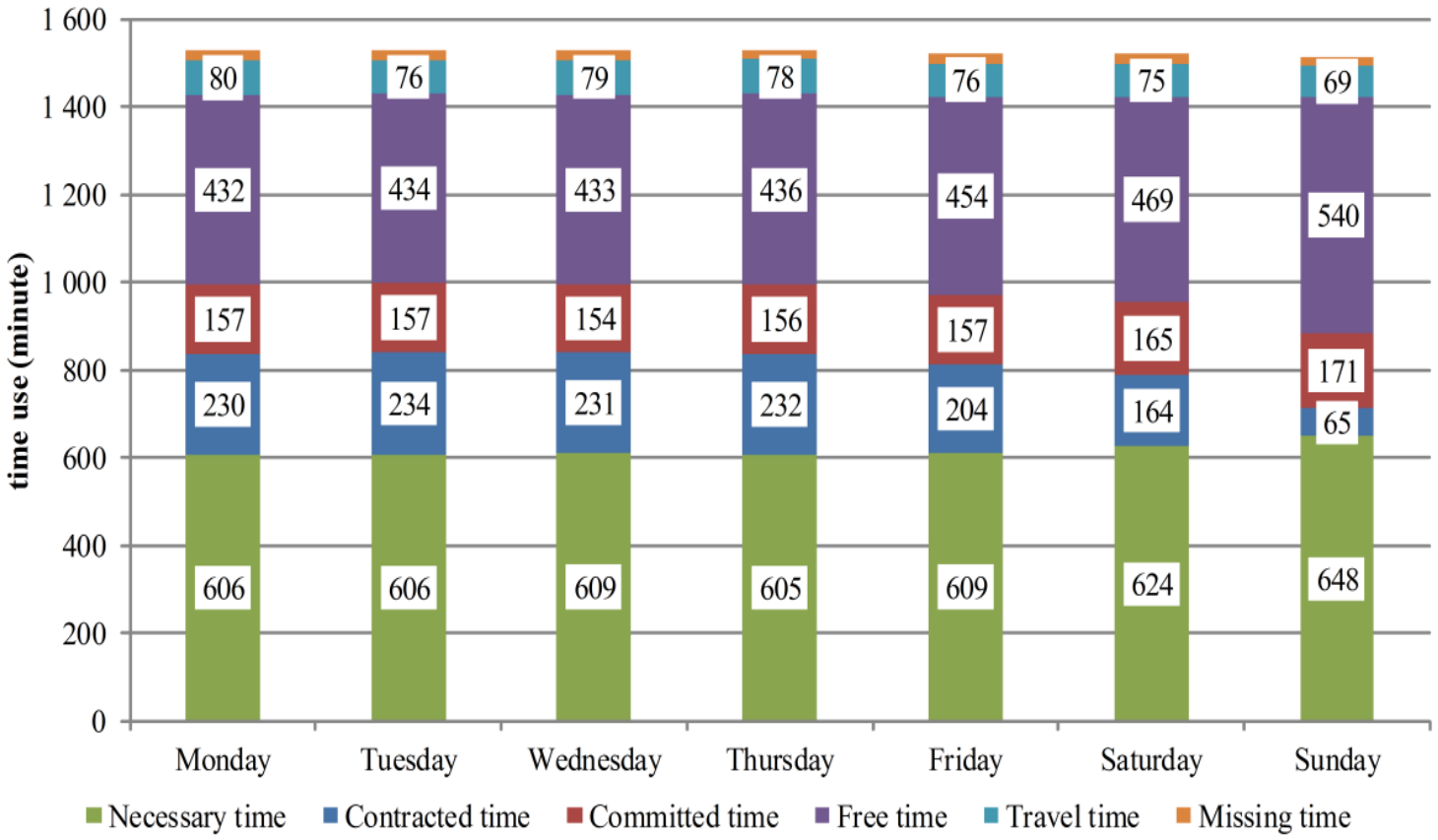
The aims of transport and land use planning beyond car movements and congestion mitigation → individual subjective well-being and happiness

Recent development in ABA includes trade-offs, unseen limit (time budget and meaning of time), and decision making processes

# Definition

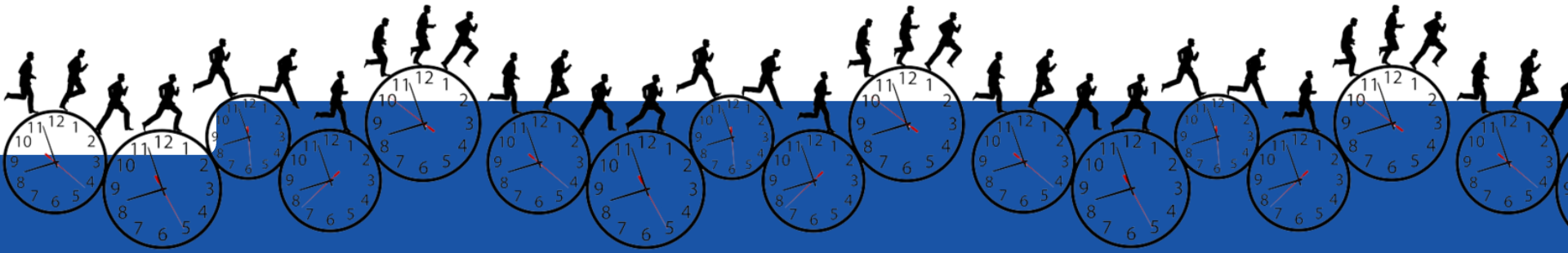
| Activity categories | Original activity classification in the survey |
|---|---|
| Contracted time | Work |
| | School |
| Committed time | Household activities, such as cleaning the house, cooking or baking, washing cloth/dishes, etc. |
| | Babysitting activities including babysitting, playing with the baby, feeding the baby, etc. |
| | Selling and purchasing activities |
| | Daily grocery shopping |
| | Picking/dropping children |
| Necessary time | Sleeping |
| | Personal care activities, such as taking a bath, brushing teeth etc. |
| | Eating/drinking at home |
| | Organization/volunteer/political activities, such as youth/political/religious meetings, visiting mosque, etc. |
| | Maintenance activities, including going to hospital/health centre/medical doctor, visiting bank/post office |
| | Fixing mechanics, such as go to a mechanic store |
| Free time | Relaxing activities, such as watching TV, listening to radio, reading newspapers, relaxing, etc. |
| | Social/family activities, such as chatting with family members, visiting friends, etc. |
| | Eating/drinking outside, such as eating in a restaurant |
| | Sports activities, such as going to a gym, playing football, etc. |
| | Holiday |

# Time use allocations across days



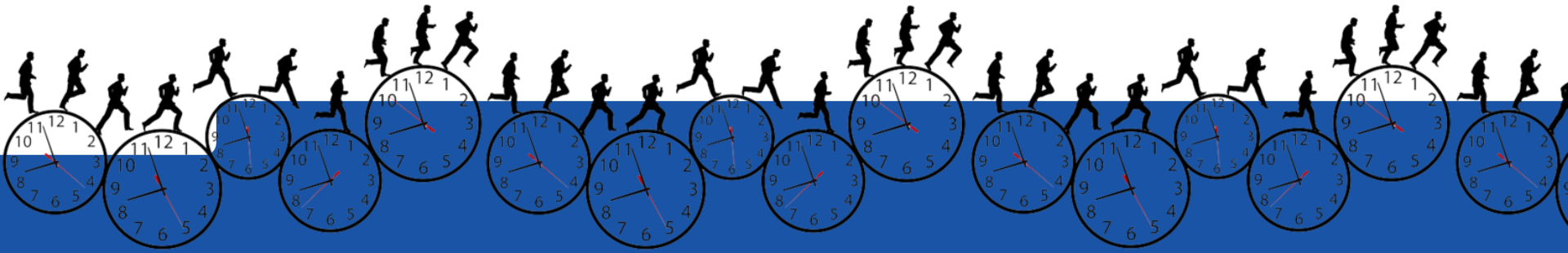
# Weekday time use distribution

| | | Necessary time | Contracted time | Committed time | Free time | Travel time | Missing time |
|---|---|---|---|---|---|---|---|
| **Household income** | Low income | 606.9*** | 217.6*** | 166.3** | 440.8 | 71.8*** | 27.8*** |
| | Medium income | 595.9*** | 230.8*** | 169.9** | 443.3 | 95.7*** | 10.7*** |
| | High income | 620.7*** | 190.4*** | 147.1** | 438.7 | 92.5*** | 23.6*** |
| **Gender** | Male | 594.1*** | 295.1*** | 77.7*** | 442.7*** | 98.2*** | 20.8*** |
| | Female | 622.8*** | 146.7*** | 246.8*** | 431.2*** | 54.3*** | 27.3*** |
| **Occupation** | Permanent worker | 581.0*** | 329.3*** | 89.3*** | 400.7*** | 106.9*** | 31.1*** |
| | Temporal worker | 585.4*** | 355.8*** | 94.6*** | 366.0*** | 88.9*** | 29.3*** |
| | Part-time worker | 598.4*** | 187.0*** | 205.9*** | 380.9*** | 78.6*** | 67.5*** |
| | Non-worker | 681.3*** | 81.3*** | 191.2*** | 528.9*** | 45.1*** | 10.1*** |
| | Student | 621.9*** | 297.0*** | 48.2*** | 438.7*** | 89.4*** | 3.5*** |
| | Household wife | 626.8*** | 44.3*** | 324.6*** | 486.6*** | 38.6*** | 14.8*** |
| | Retired | 692.3*** | 33.5*** | 167.4*** | 612.5*** | 59.7*** | 1.1*** |
| | Others | 554.5*** | 194.6*** | 174.2*** | 494.0*** | 77.7*** | 48.6*** |

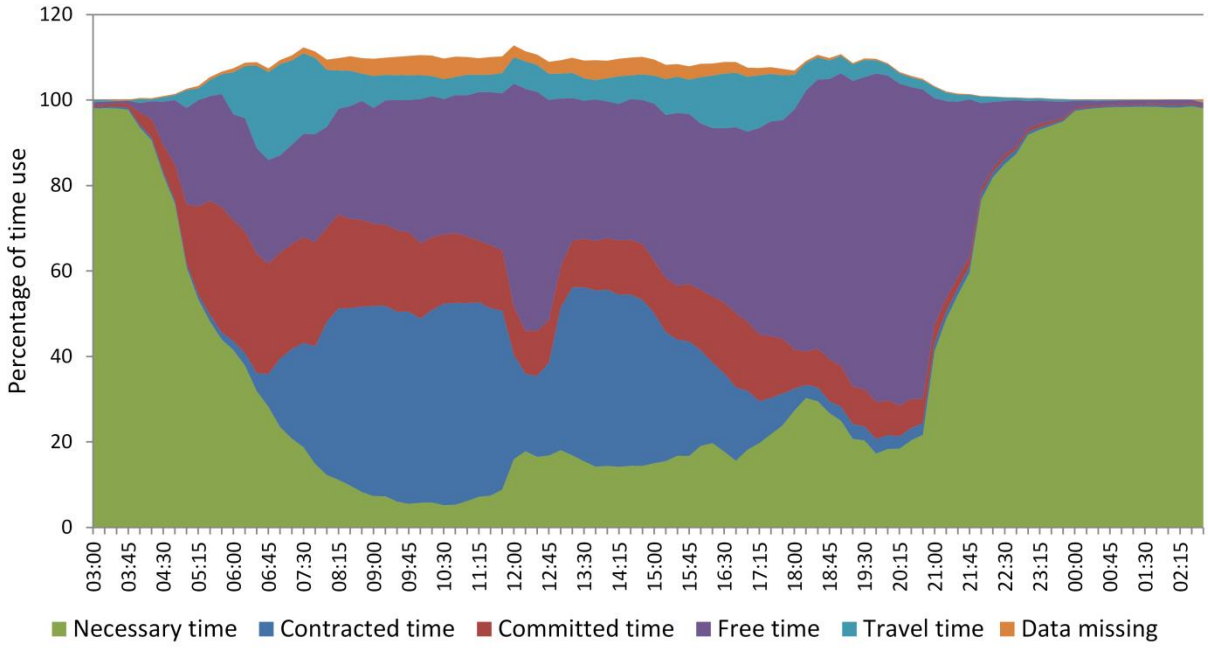


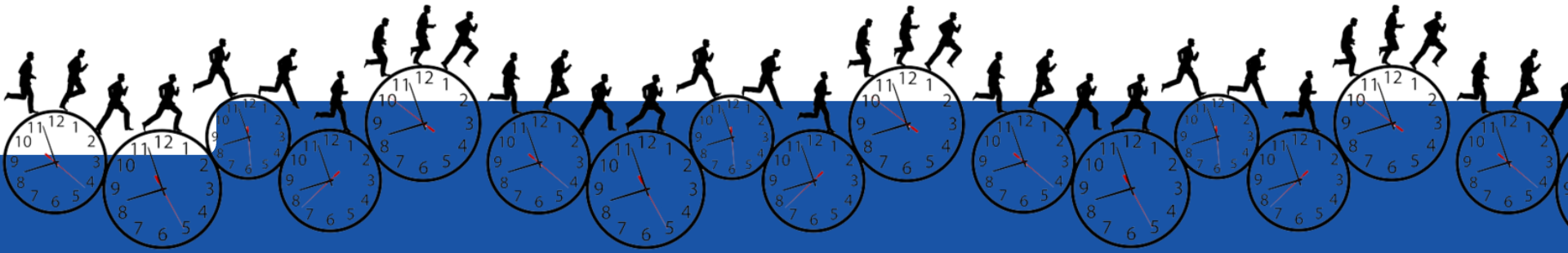
# Weekend time use distribution

| | | Necessary time | Contracted time | Committed time | Free time | Travel time | Missing time |
|---|---|---|---|---|---|---|---|
| **Household income** | Low income | 637.2 | 111.1*** | 179.0*** | 497.7*** | 66.6*** | 25.1*** |
| | Medium income | 627.5 | 112.3*** | 187.3*** | 512.4*** | 80.4*** | 11.5*** |
| | High income | 635.4 | 94.2*** | 143.7*** | 529.4*** | 90.4*** | 10.2*** |
| **Gender** | Male | 628.4*** | 152.7*** | 89.3*** | 534.2*** | 86.7*** | 20.0 |
| | Female | 645.1*** | 71.1*** | 258.5*** | 469.5*** | 54.8*** | 22.0 |
| **Occupation** | Permanent worker | 630.1*** | 165.4*** | 117.0*** | 501.4*** | 83.5*** | 23.6*** |
| | Temporal worker | 616.6*** | 159.3*** | 140.6*** | 486.1*** | 80.9*** | 26.1*** |
| | Part-time worker | 618.9*** | 129.5*** | 205.2*** | 405.9*** | 75.9*** | 72.1*** |
| | Non-worker | 676.6*** | 70.5*** | 185.4*** | 543.9*** | 49.0*** | 7.9*** |
| | Student | 673.8*** | 126.3*** | 66.0*** | 545.2*** | 82.2*** | 2.8*** |
| | Household wife | 633.4*** | 23.1*** | 312.8*** | 492.1*** | 48.0*** | 13.1*** |
| | Retired | 687.2*** | 26.5*** | 152.8*** | 625.8*** | 74.0*** | 0.3*** |
| | Others | 569.1*** | 167.7*** | 128.8*** | 506.3*** | 72.1*** | 47.7*** |

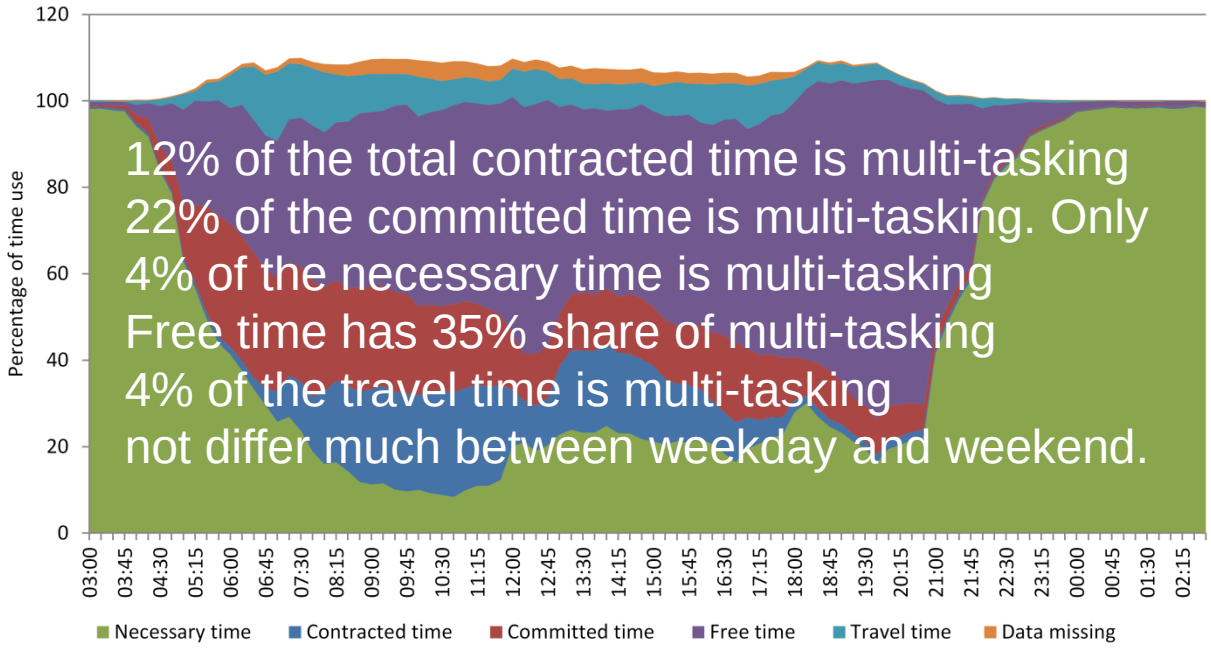


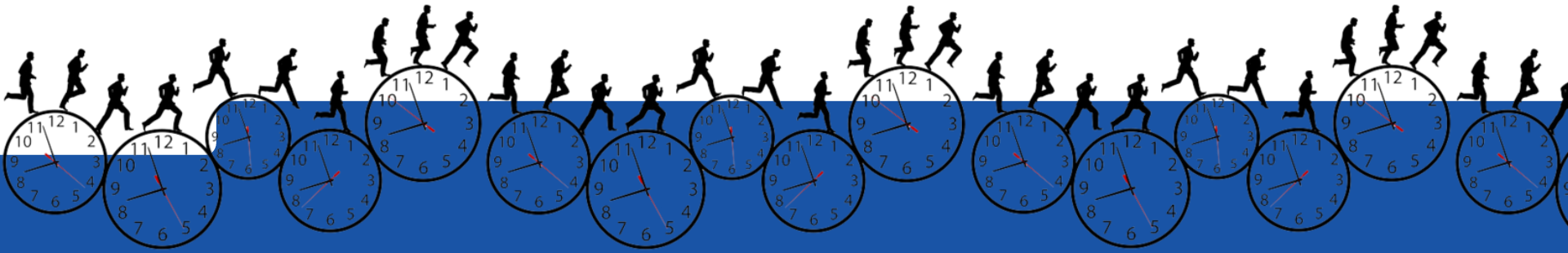
# Time use distribution across the time of the day (on weekday)



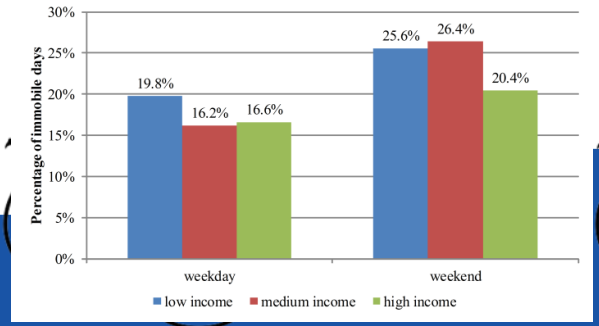
# Time use distribution across the time of the day (on weekend)

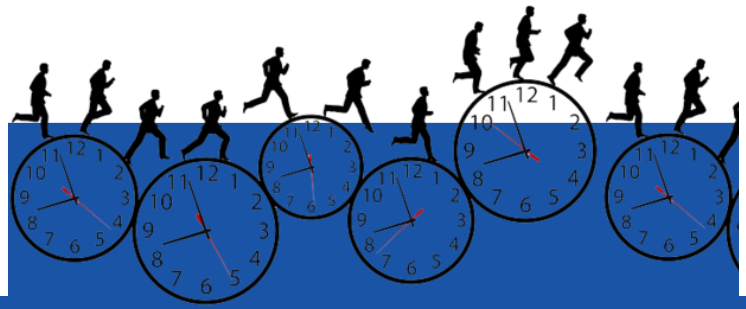


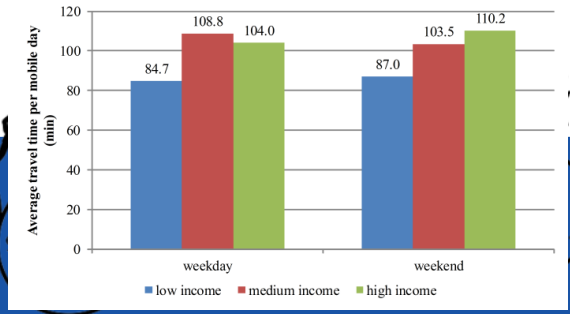



# The immobile days and average travel time per day

| | | Percentage of immobile days | | Average travel time per mobile day | |
|---|---|---|---|---|---|
| | | Mean (%) | S.D. | Mean (min) | S.D. |
| **Household income** | Low income | 21.41* | 0.30 | 85.4*** | 48.1 |
| | Medium income | 19.10* | 0.26 | 106.3*** | 68.6 |
| | High income | 17.70* | 0.30 | 90.5*** | 53.2 |
| **Gender** | Male | 11.64*** | 0.21 | 105.4*** | 59.4 |
| | Female | 29.35*** | 0.34 | 72.7*** | 37.6 |
| **Occupation** | Permanent worker | 9.68*** | 0.19 | 107.7*** | 61.4 |
| | Temporal worker | 12.00*** | 0.19 | 96.9*** | 51.5 |
| | Part-time worker | 17.41*** | 0.29 | 88.7*** | 53.9 |
| | Non-worker | 38.69*** | 0.37 | 68.7*** | 40.5 |
| | Student | 10.44*** | 0.18 | 97.7*** | 39.2 |
| | Household wife | 37.79*** | 0.36 | 63.3*** | 36.2 |
| | Retired | 40.91*** | 0.37 | 100.9*** | 77.1 |
| | Others | 16.26*** | 0.28 | 88.8*** | 53.7 |





# Who are more immobile than others?

Binnary logit model with panel data

$$U_{i,j,k} = X_{i,j}\beta_k + \mu_{i,k} + \varepsilon_{i,j,k}$$

$$P_{i,j,k} = \int_{-\infty}^{+\infty} \frac{e^{U_{i,j,k}}}{\sum_{m=1}^{2} e^{U_{i,j,m}}} f(\mu_{i,k}) d\mu_{i,k}$$

| Reference alternative: mobile | Coefficients |
|---|---|
| Friday | + |
| Saturday and Sunday | ++ |
| Female | +++ |
| Age 26-35 years old | -- |
| Age 46-55 years old | -- |
| Age over 55 years old | +++ |
| High income: >IDR 6 million/month (approx. 600 USD/month) | -- |
| Number of household members | - |
| Number of motorised vehicles per household member | --- |
| Perceived number of public transport lines connected to home | - |
| Perceived travel time from home to CBD | + |
| Perceived travel time from home to nearest park | + |
| Perceived travel time from home to nearest station | - |
| Population density at the home zone | + |

# How different people spend their time across the observed 21 days?

A series of log-linear multilevel models are estimated to explore the determinants of time use.

$$\log\left(T_{m,i,j}^{k}\right) = X_{m,i,j}^{k}\beta^{k} + \tau_{m}^{k} + \mu_{m,i}^{k} + \varepsilon_{m,i,j}^{k}$$

| | Contracted time | Committed time | Necessary time | Free time |
|---|---|---|---|---|
| Friday | - | | | + |
| Saturday and Sunday | - | + | + | + |
| Female | - | ++ | + | - |
| Age 14-25 years old | + | - | + | + |
| Age 26-35 years old | | | + | + |
| Age 46-55 years old | | | + | + |
| Age over 55 years old | - | | + | + |
| Number of household members | | - | | - |
| Number of motorised vehicles per household member | - | -- | + | |
| Perceived number of public transport lines connected to home | + | | - | |
| Perceived travel time from home to CBD | | | | + |
| Perceived travel time from home to nearest grocery store | | + | | |
| Perceived travel time from home to nearest shopping centre | + | - | | - |
| Perceived travel time from home to nearest train station | | + | | - |
| Population density at the home zone | - | | | |
| Road density at the home zone | | | - | |
| Industrial area density at the home zone | | --- | | |
| Commercial area density at the home zone | | | | ---- |

# Physical, social, and mental health data

Health-related QoL was developed based on SF-36 (Short-Form 36), which are measured in categories such as physical functioning (PF), limitations on role functioning according to physical health (RP), bodily pain (BP), general health (GH), mental health (MH), limitations on role functioning due to emotional problems (RE), social functioning (SF) and vitality (VT).
As suggested by Suzukamo et al. (2011), PF, RP and BP will be defined as physical health, RP, SF and RE as social health, and GH, VT, SF, MH as mental health.

This questionnaire also included detailed questions about physical activities in order to determine the average daily physical activities of individuals (as based on the International Physical Activities Questionnaire (IPAQ) ( http://ipaq.ki.se) (Hägstromer et al., 2007)

| Category | Description |
|---|---|
| Physical activities | 1. Body weight and height<br>2. Vigorous activities as part of the individual's work/school activities and around the home environment<br>3. Moderate activities as part of the individual's work/school activities and around the home environment<br>4. Walking as part of the individual's work/school activities (excluding travel activities)<br>5. Travel activities using a motorised mode/s<br>6. Non-motorised transport activities (cycling and walking)<br>7. Activities performed sitting down |
| Physical activities in leisure time as part of health promoting activities | 1. Objective and subjective measurement of walking<br>2. Objective and subjective measurement of vigorous active exercise with and without bodily collision, such as soccer, basketball, running, playing tennis/badminton, fast cycling, aerobics, swimming, etc.<br>3. Objective and subjective measurement of moderate active exercise with and without bodily collision, such as light cycling, light swimming, light tennis/badminton, etc. |
| Social and communication activities with family members and other people | 1. Social and communication activities with other people, such as voluntary and organisational activities, attending events and socialising at events<br>2. Social and communication activities with other family members |
| Lifestyle and health habits | Eight types of habits: eating breakfast, enough sleep, eating balanced meals, smoking, drinking alcohol, working less than nine hours each day, under stress/pressure circumstances |
| Health-related quality of life | 1. Subjective measurement of an individual's health and comparison with the previous year<br>2. Physical functioning<br>3. Limitations on role functioning due to physical health<br>4. Bodily pain<br>5. General health<br>6. Mental health<br>7. Limitations on role functioning due to emotional problems<br>8. Social functioning<br>9. Vitality |

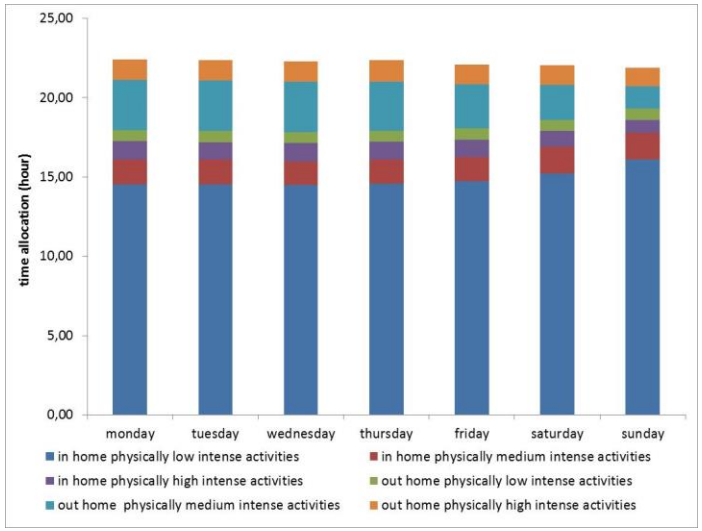
# Classification of activity and its intensity

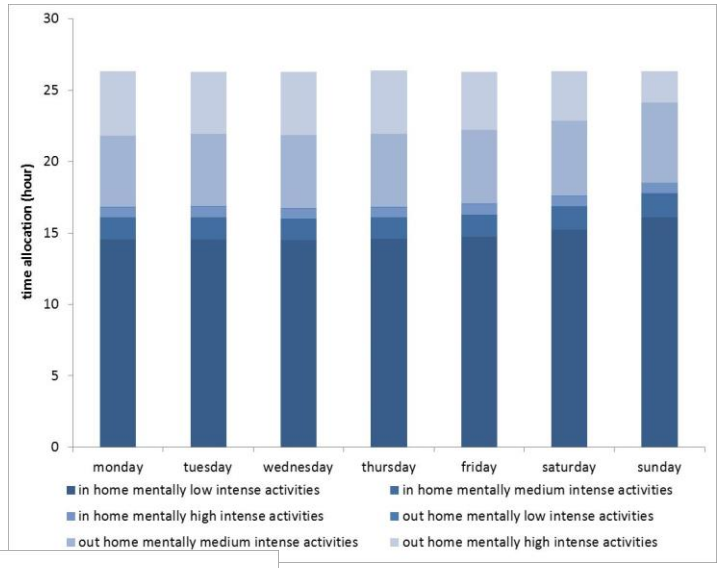
| | Type of Activities | Level of intensity of engagement | | |
|---|---|---|---|---|
| | | Physically | Mentally | Socially |
| A | Sleeping | L1 | L1 | L1 |
| B | Personal care: taking a bath, brushing teeth, self-care etc. | L1 | L1 | L1 |
| C | Eating and drinking at house | L1 | L1 | M1 |
| D | Relaxing activities, such as watching tv, listening to radio, listening to music, reading newspaper/magazine/comic etc., browsing internet etc. | L1 | L1 | L1 |
| E | Social and family activities, such as chatting with other family members/friends in person or via phone, walking/biking with other family members/friends, visiting relatives/friends, weekly praying etc. | M2 | M2 | H2 |
| F | Household activities, such as house cleaning, cooking, baking a cake, washing clothes/dishes, ironing, prepare a drink, etc. | M1 | M1 | L1 |
| G | Babysitting activities, including playing together and feeding your children | H1 | H1 | M1 |
| H | Indoor working activities, such as working at office desk, doing indoor research or experiment in laboratory, “meeting” with clients at phone, etc. | M2 | H2 | M2 |
| I | Driving vehicle to other places | L2 | H2 | L2 |
| J | Outdoor working activities, such as operating machine or heavy vehicle at outdoor environment, outdoor inspection and other related activities | H2 | H2 | M2 |
| K | Sales activities from door to door, delivery and purchasing related activities | H2 | H2 | H2 |
| L | Indoor school activities | M2 | M2 | M2 |
| M | Outdoor school activities, including visiting zoo/museum/park, camping, and other related activities | H2 | H2 | H2 |
| N | Eating and drinking outside home | L2 | M2 | H2 |
| O | Shopping activities, including both local grocery shopping and shopping at a shopping centre | M2 | M2 | M2 |
| P | Participating in organization/volunteer/political activities, such as boy scout and youth/political/religious meeting activities | H2 | H2 | H2 |
| R | Sport activities | H2 | H2 | H2 |
| S | Maintenance activities, including going to hospital/health centre/medical doctor, bank and post office | M2 | H2 | H2 |
| T | Pick up and drop off children/other family members/friends/business partner and others | M2 | M2 | H2 |
| U | Holiday (away trip) | M2 | M2 | M2 |
| V | Waiting for public transport | L2 | L2 | L2 |

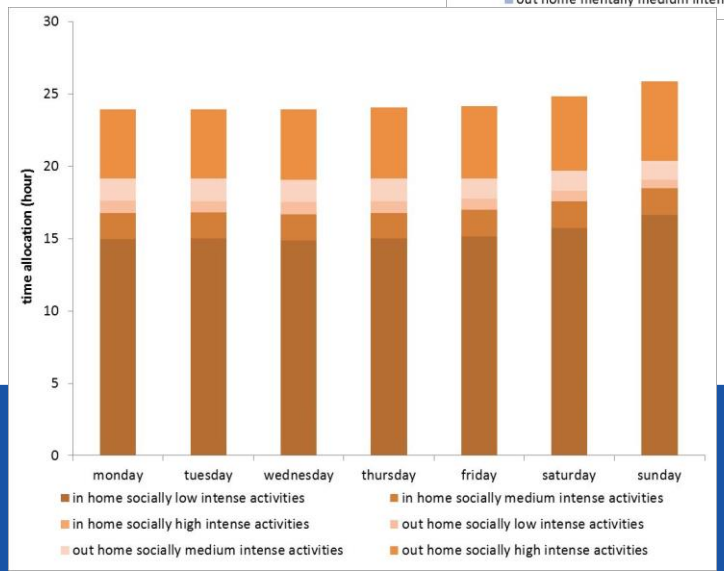
Note: 1= in-home activities, 2= out-of-home activities; with assumption of level of intensity:

| Level of intensity | Physical | Mental | Social |
|---|---|---|---|
| Low | not require any specific physical engagement | not require any in-purpose thinking | not involve any specific intension to interact with others |
| Medium | activities with some physical engagements | need to be aware/alert of surrounding, but not in intense manner | involve activity that somewhat require interactions with others |
| High | require intense physical engagements | need always to be alert (on-guard) and/or at intensive thinking | involve intense interaction activities with others |

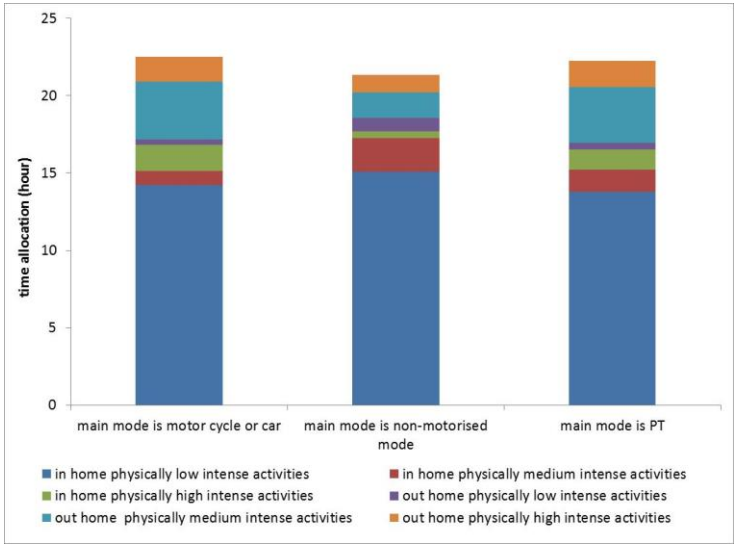
# Time allocation by day of the week

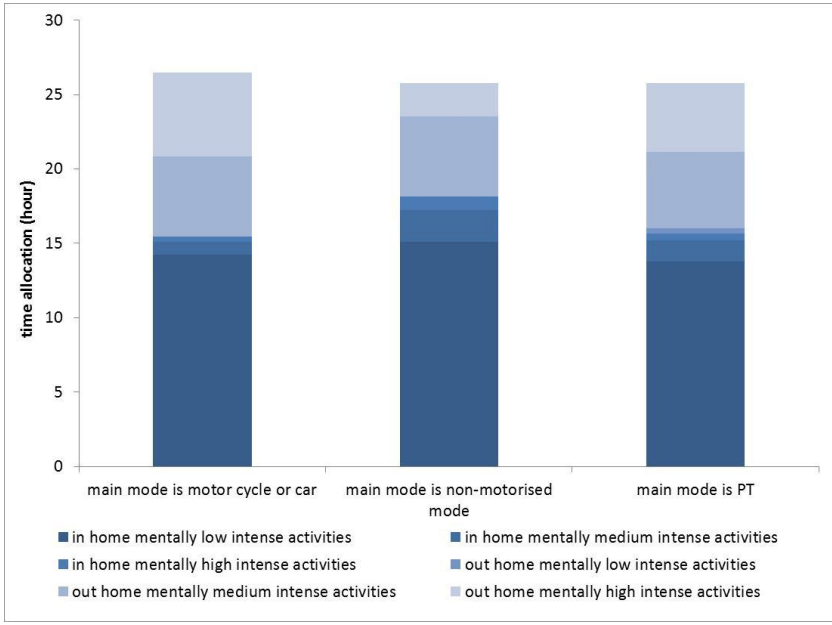


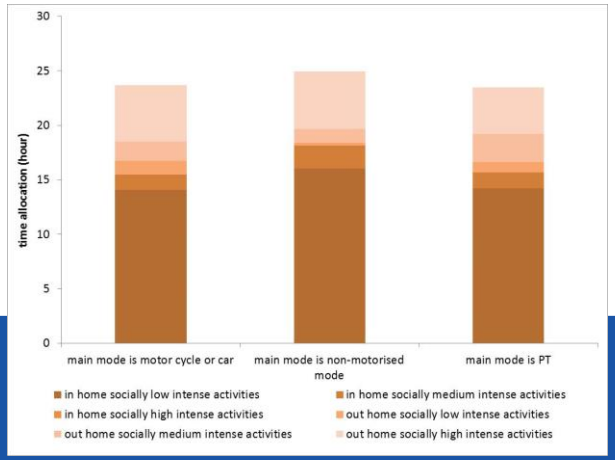



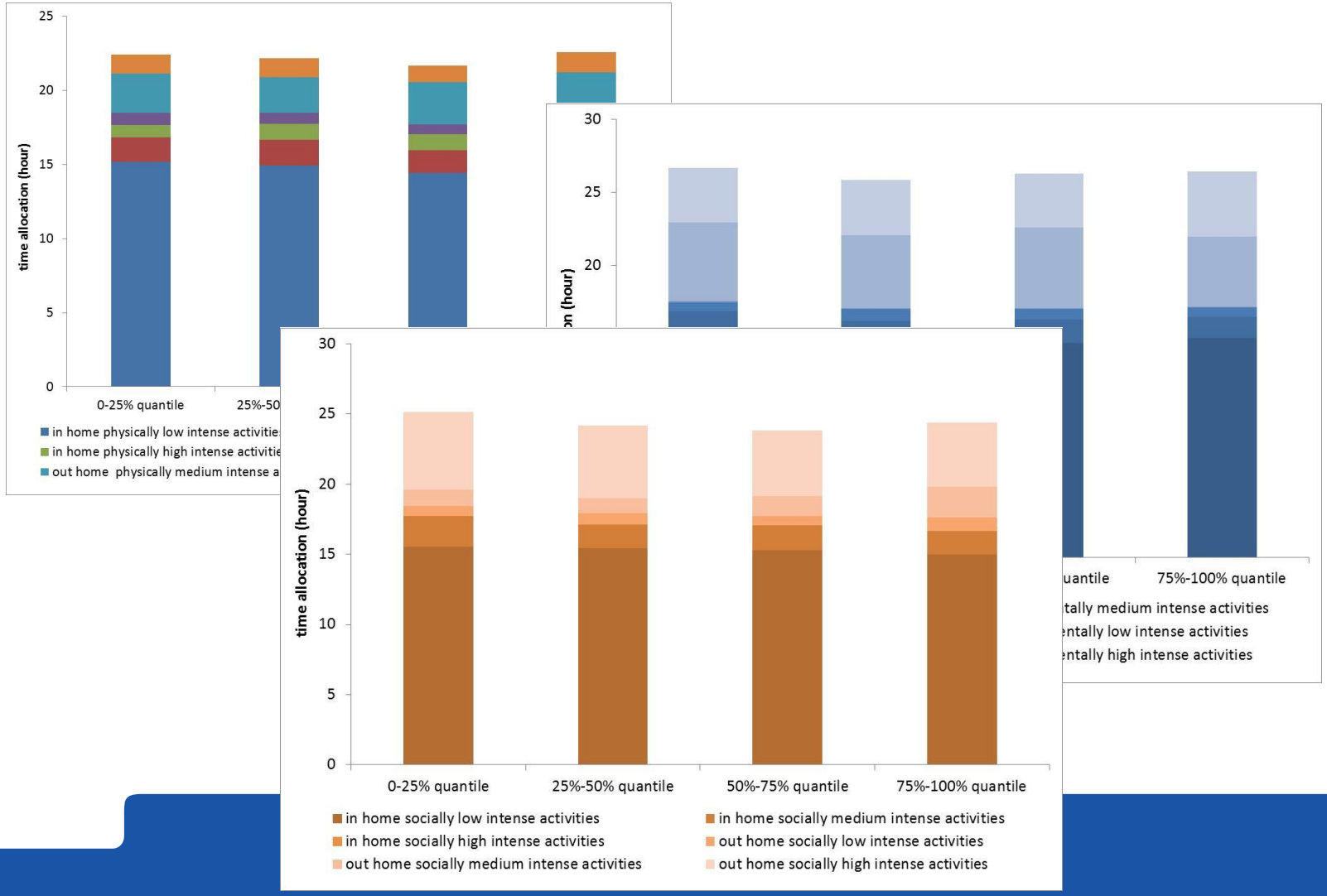
# Time allocation by chosen main mode



# Time allocation by different health conditions



# The interactions between activity participations with health conditions

Using seemingly uncorrelated regression (SUR) model:

$$\begin{cases} y_1 = \beta_1 X_1 + \alpha_1 T + \gamma_1 D + \varepsilon_1 \\ \dots \\ y_k = \beta_k X_k + \alpha_k T + \gamma_k D + \varepsilon_k \end{cases}$$

The model investigates how individuals' self-reported health conditions are affected by the time use, socio-demographics and residential environment. The model is treated as a path model and is estimated via the structural equation modelling framework.

| | Self-reported physical health | | Self-reported mental health | | Self-reported social health | |
|---|---|---|---|---|---|---|
| | Estimates | T-value | Estimates | T-value | Estimates | T-value |
| Activity duration | | | | | | |
| In-home low intense a | | | | | | -2.27 |
| In-home medium inte | | | | | | / |
| In-home high intense | | | | | | / |
| Out-of-home low intense activities | 0.12 | | | | | |

Individuals' activity participation significantly affects their self-reported health conditions, while their travel choices only affect the physical health condition but not mental and social health conditions.

non-motorised travel time, however, shov
significant correlation on self-reported ph
health condition

| | | | | | | |
|---|---|---|---|---|---|---|
| Travel time | | | | | | |
| Non-motorised mode tra | | | | | | 1.20 |
| Motorised mode travel t | | | | | | -0.72 |
| Public transport travel ti | | | | | | -2.50 |
| Individual socio-demogr | | | | | | 2.84 |
| Female | | | | | | -1.66 |
| | | | | | | -0.51 |
| | | | | | | 1.52 |

"The walks make me get up and get myself moving I like walking and it helps my blood pressure. I feel better and more confident."

Older respondents reported physical no significant correlation. Population density positively correlates to self-reported physical health condition.

Longer (both in-home and out-of-home) mentally high intense activity durations correspond to a higher self-reported mental health condition, while out-of-home mentally low intense activity duration corresponds to a lower self-reported mental health condition. Being a part-time worker would have a lower self-reported mental health condition compared to a full-time worker. Population density positively correlates to self-reported mental health condition.

A longer in-home socially low intense activity duration corresponds to a lower self-reported social health condition; whereas a longer out-of-home socially low and medium intense activity duration corresponds to a higher self-reported social health condition.

Older people and part-time workers have a lower self-reported social health condition. Those who live in large households also tend to have higher self-reported social health compared to those living in small households. Those who live in more densely populated areas tend to have a higher self-reported social health than those in rural areas.

# So, what we can learn from the results?

- Day-to-day variability of individuals' activity-travel time use.
- On average, individuals only spent around 4-5% of their time on travel, whilst In-home activities such as sleeping, in-home preparation and eating activities take more than 75% of individuals' daily time expenditure.
- Did not find evidence of positive relationship between cycling and walking and self-reported physical health condition, which has been found in many developed countries.
- Age and working status were also found significantly affect the self-reported health conditions, regardless of respondents' gender and income.
- Population density also found positively correlates to self-reported respondents' health conditions
- Perceived (subjective) accessibility measures play more important roles in affecting immobile behaviour and time use allocations than residential built environment measures.

# How does the result has been different than developed countries'?

- Different distribution of time use allocation
- No income effects on the distribution – though high income is still the more mobile one.
- More significant gender differences on time use allocation

- Different priorities, different activity participations, different trip patterns, different traffic movements


# THANK YOU

QUESTIONS?

*Yusak O. Susilo; yusak.susilo@abe.kth.se*