Health Co-benefits from Mitigating Climate Change through Mass Rapid Transit System in Greater Kuala Lumpur

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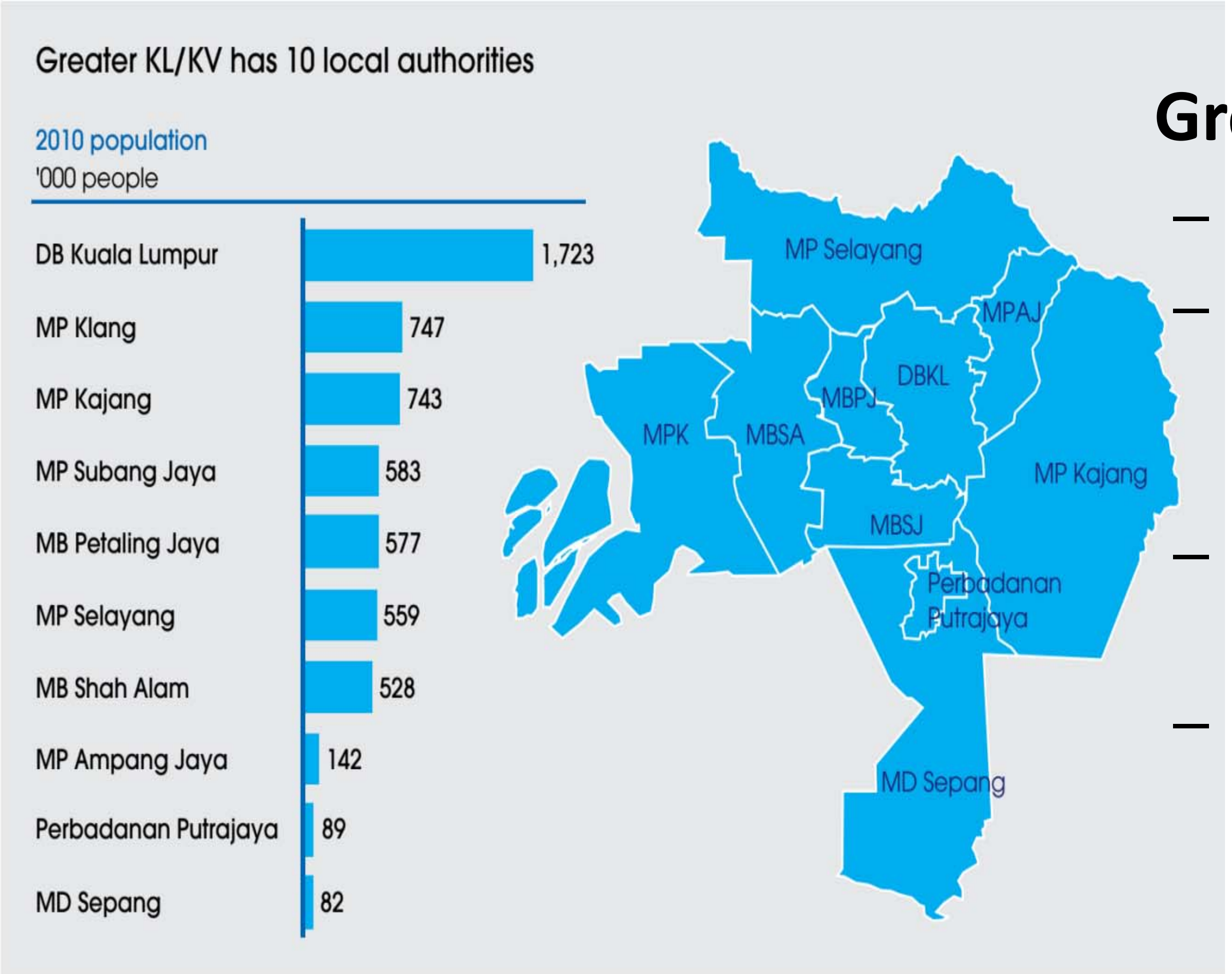
Introduction

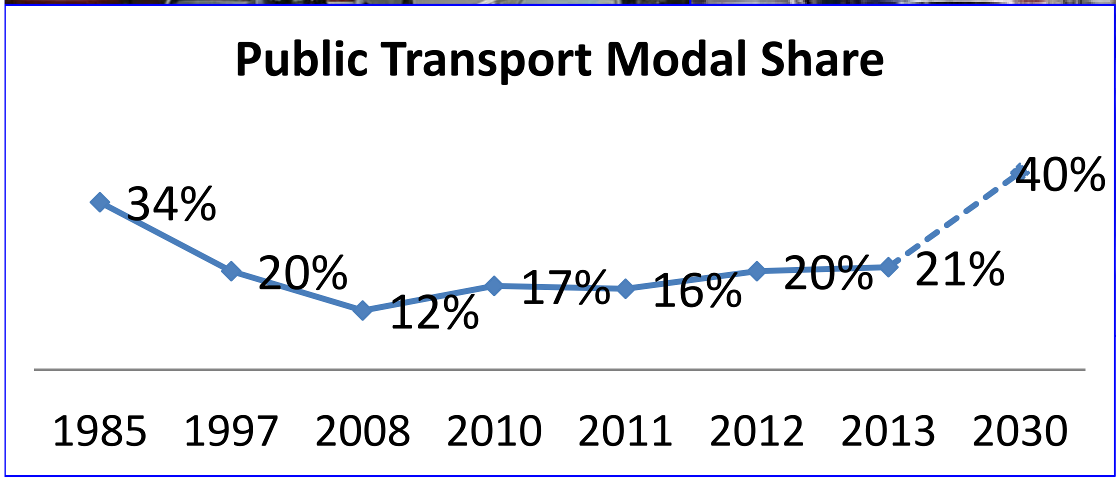


SOURCE: Department of Statistics

Greater Kuala Lumpur

- 10 local authorities
- Population: 7.2 million (2016) to 10 million (2020) (39%)
- contributing 37% of the GDP in Malaysia (2010)
- aspire to become one of the most livable cities

Cars…

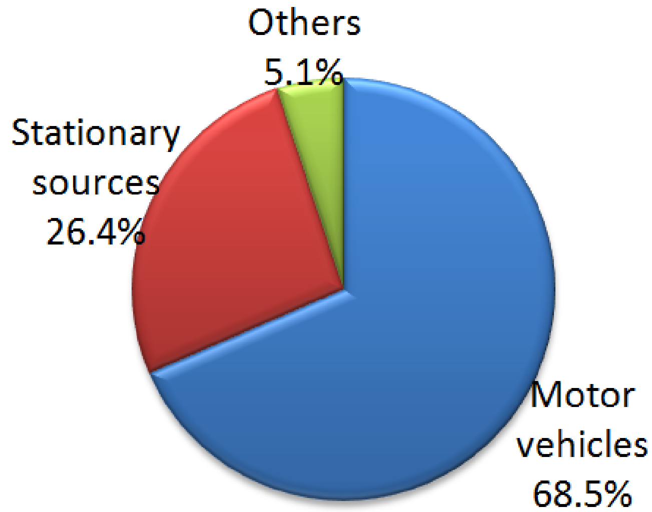


Source: GTP 2010; 2012; SPAD 2014

- 83% trips were private automobile with 70% single occupancy vehicle (Ministry of Finance 2011; Mohamad and Kiggundu 2007)
- Transport is second highest carbon emitter 21% (NRE 2011)
- Malaysia to reduce GHG emissions intensity of GDP by 45% by 2030 relative to 2005 in Paris agreement (UNFCCC 2016)

- Traffic contributed 36% of the urban PM2.5 in SEA against global 25% (Karagulian et al. 2015)
- In Malaysia, motor vehicles were the biggest source of PM2.5 emissions (Compendium of Environment 2013; Rahman et al. 2011)

Source of air pollutant emissions in Malaysia



- Motorized road transport resulted in 1.5 million deaths and 79.6 million healthy years of life lost annually from air pollution and injuries (The World Bank & IHME 2014)
- Transport is a potential means to improve the PA level in the urban population of GKL (Poh et al. 2010; Chu and Foong 2013)

Rank	Cause
1	Ischemic heart disease
2	Stroke
3	COPD
4	Lower respiratory infections
5	Lung cancer
6	HIV/AIDS
7	Diarrheal diseases
8	Road injury
9	Diabetes mellitus
10	Tuberculosis

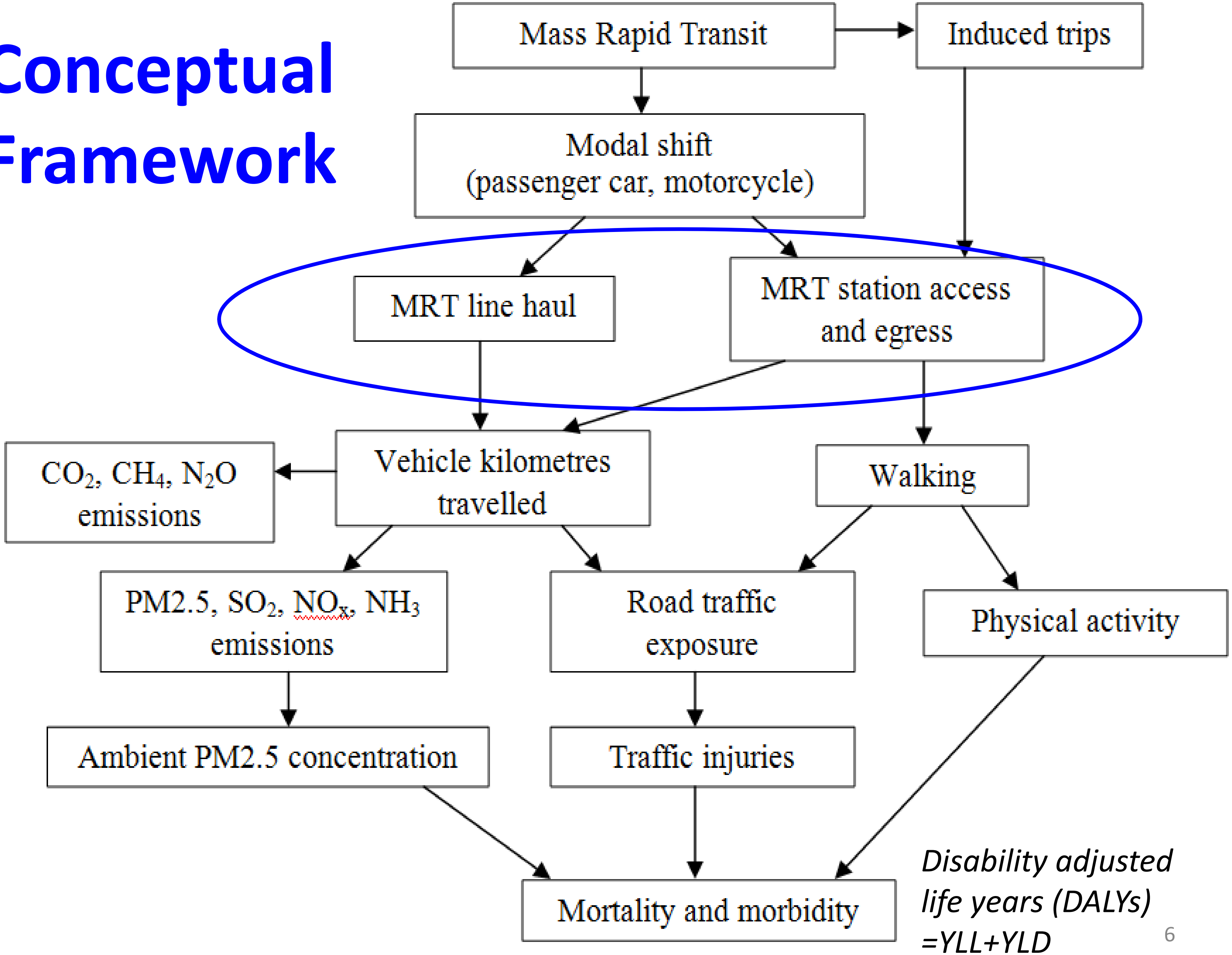
Mass Rapid Transit (MRT)

- 3 lines, 150 km
  - **Sg.Buloh-Kajang (SBK)**
  - Sg.Buoh-Serdang-Putrajaya (SSP)
  - Circle Line
- Cost RM 80 billion (US$ 20 billion)

MRT line	SBK
Length (km)	51
Stations	31
Construction	2011-2017
Daily ridership	442,000

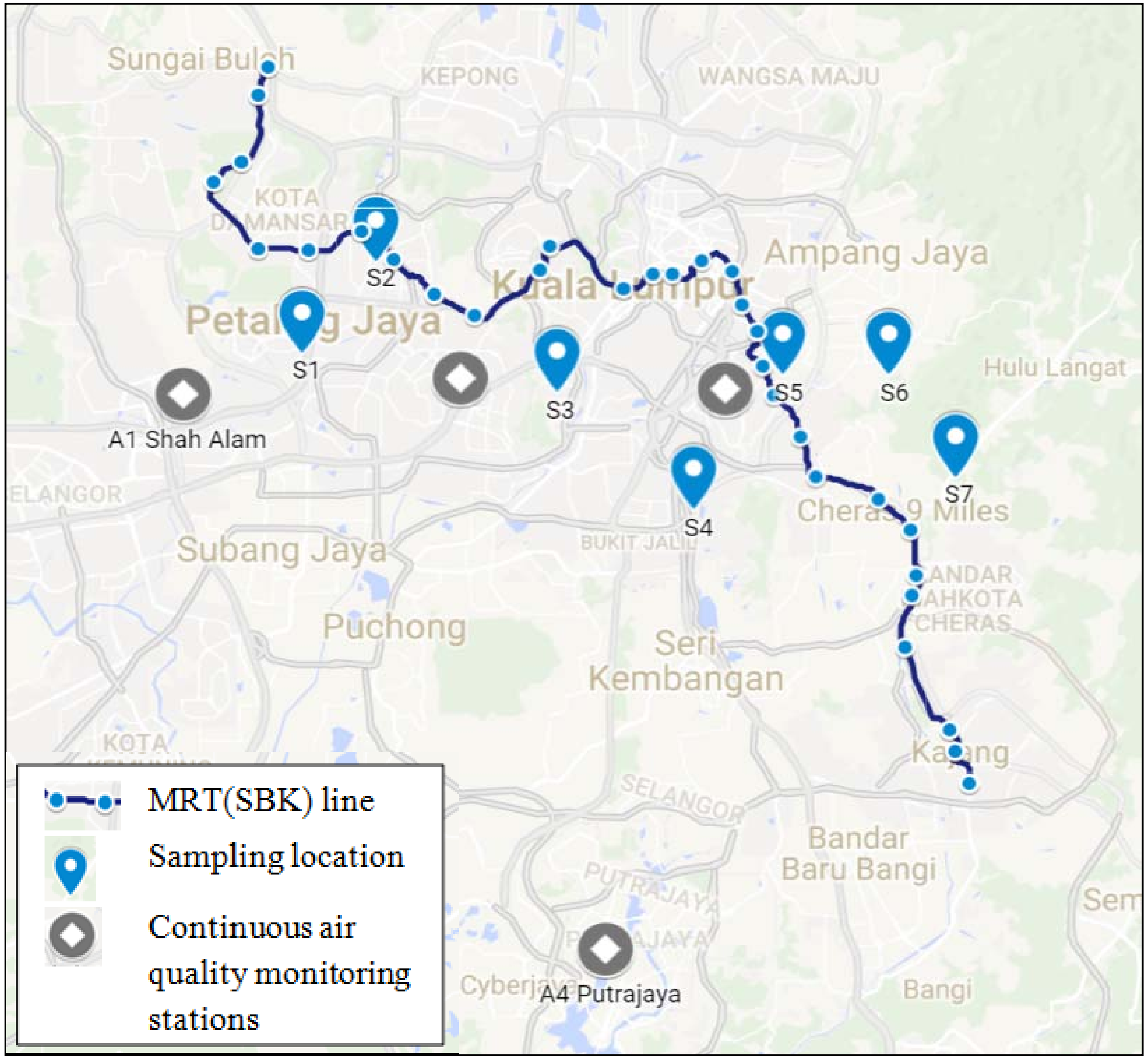
How much carbon reduction and health co-benefits could be generated?

Conceptual Framework



Disability adjusted life years (DALYs) =YLL+YLD

Method



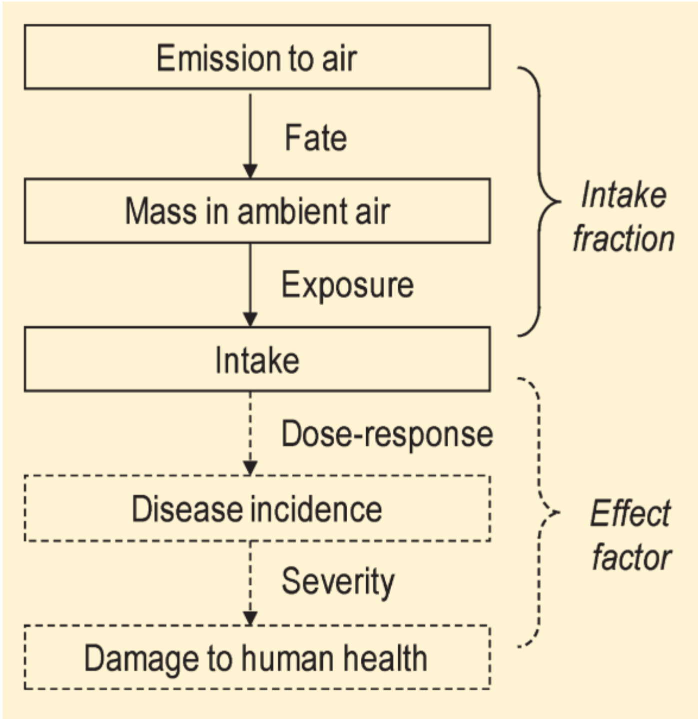
Travel survey

- Cross sectional
- 7 locations within 5 km to 8 stations of MRT (SBK)
- Survey period: Feb 2015 – Jun 2015
- Travel information:
  - Transport mode
  - Trip distance
  - Trip duration
  - Trip purpose

Calculations

Emission changes = ∑ [M_{mode} (VKT_M) (EF_M)]

- **M_{mode}**: Ridership x 365 days and modal shift (33% motorcycle, 66% cars, 1%bus) (EIA, 2011)
  induced trips (15%) (Goel&Tiwari, 2015)
- **VKT:** Line haul & station access (survey)
- **Emission factors** (GEF, 2010; Griffin, 2014; NAEI, 2013):
  - Greenhouse gases (N_2O, CH_4, CO_2),
  - Primary PM2.5,
  - PM2.5 precursors (NOx, SOx, NH_3),
  - re-entrained dust (road abrasion, tyre wear, tyre brake),
  - vehicle cold start (per trip)



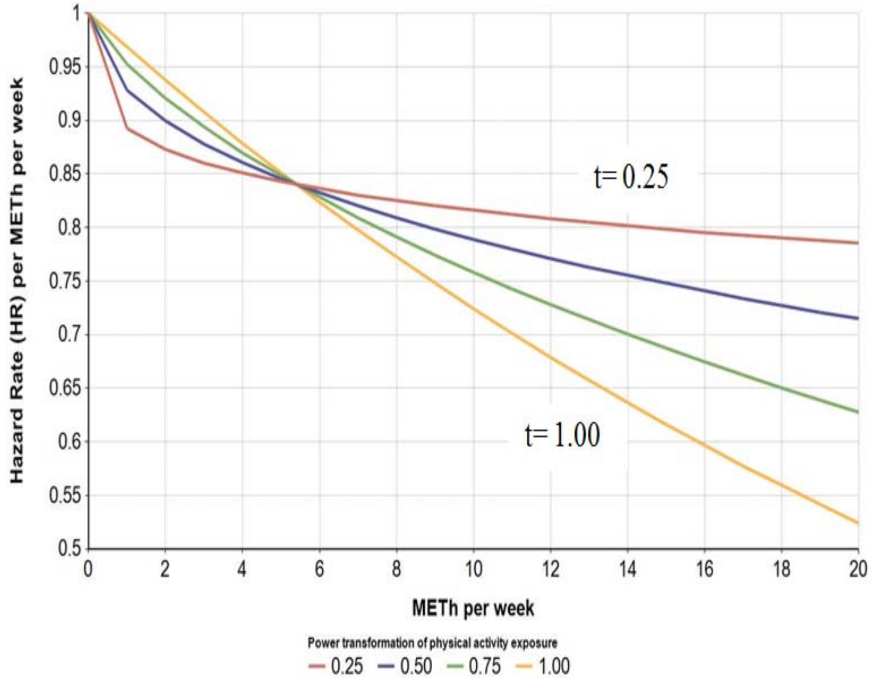
Source: Humbert et al. 2011

PM2.5 concentration (mg/m^3) = (iF(ppm)*emissions(kg))/breathing rate ($m^3 person^{-1} day^{-1}$)

- PM2.5 concentrations: Intake fraction (Humbert et al., 2011; Apte et al., 2012)

- Comparative health risk assessment (Ezzati et al. 2004):
- Baseline data:
  - CAQM stations (DOE 2008-2013)
  - Number of traffic injury (MIROS 2007-2013)
  - Physical activity level (NHMS 2006)
  - Global burden of disease 2010
- Relative risks:
  - Air pollution: Ostro, 2004 linear
  - Traffic injury: death/injury per exposure km, linear
  - Physical activity: ITHIM, curvilinear
- Impact population:
  - Air pollution: population catchment
  - Traffic injury & physical activity: new MRT users

$$PAF = \frac{\sum_{i=1}^{n} P_i RR_i - \sum_{i=1}^{n} P'_i RR_i}{\sum_{i=1}^{n} P_i RR_i}$$



Power transformation of RR for stroke in male (Gotschi et al. 2015)

Results

Transport modal share:

Transport mode (n=474)	%
Car driver	54.2
Car passenger	5.1
Motorcycle	17.5
Bus	2.6
Rail	9.6
Taxi	0.6
Walk	3.3
Cycle	0.2
Total	100

77% private vehicle
13% public transport

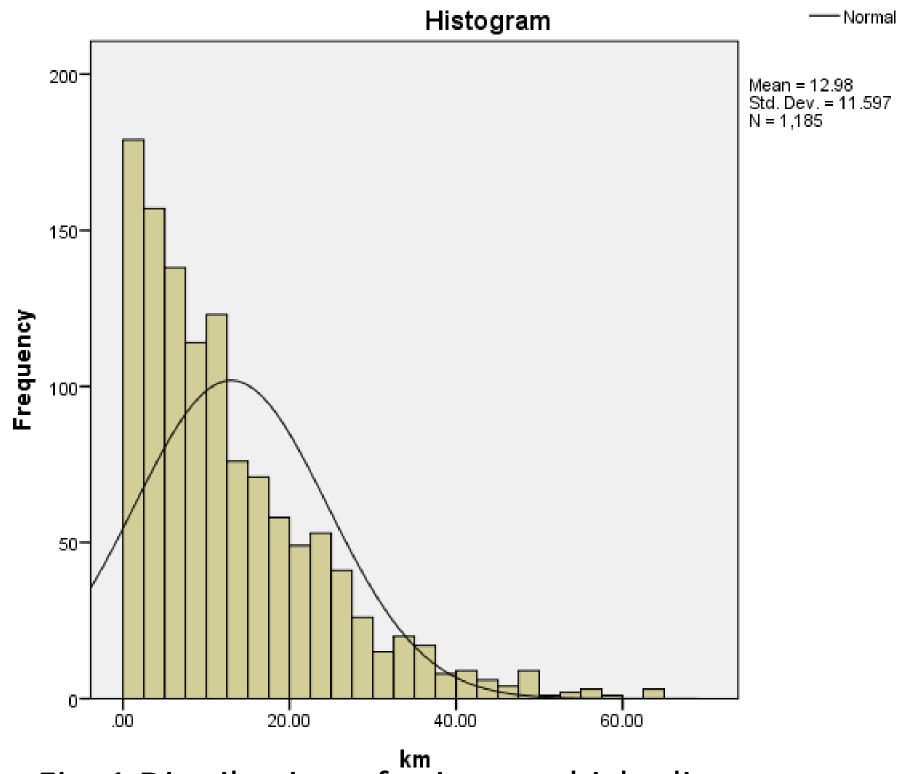
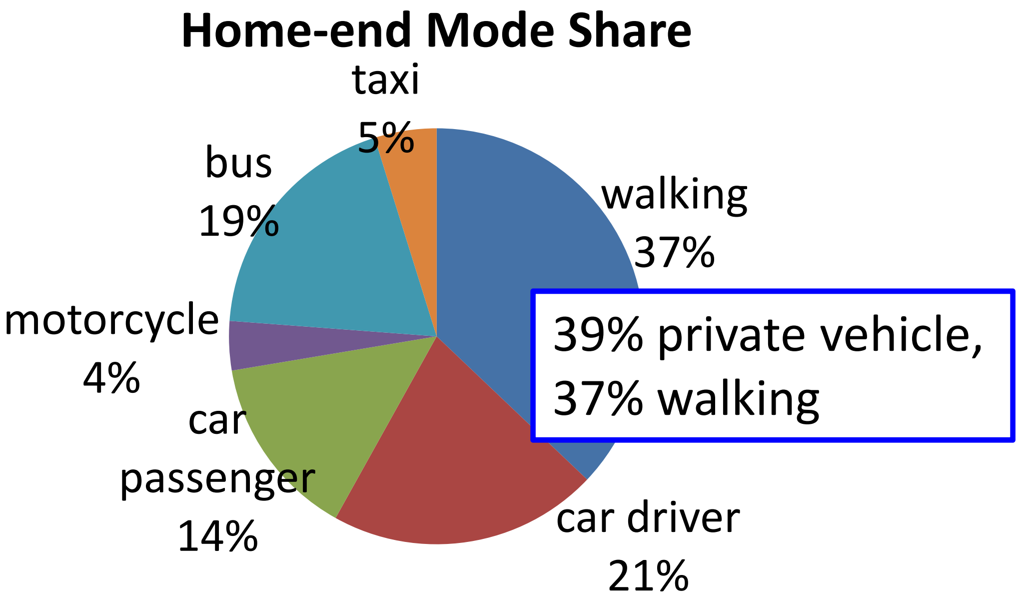
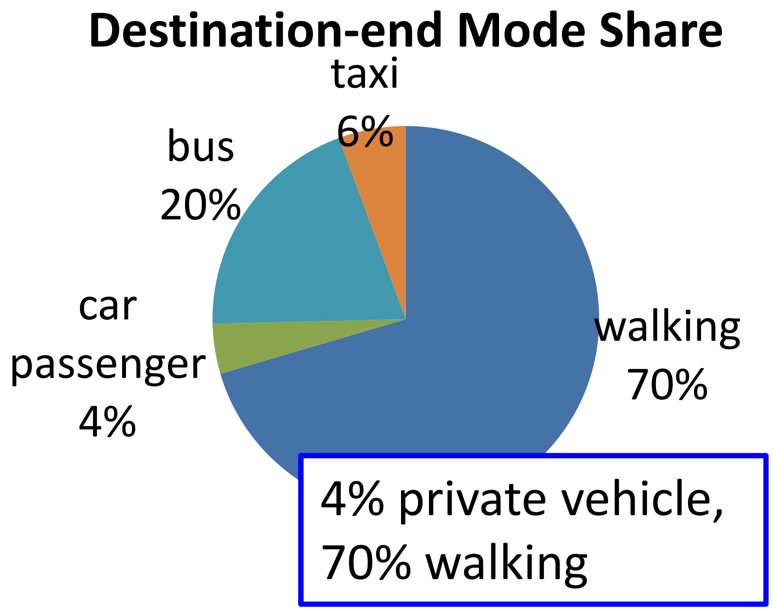


Fig. 1 Distribution of private vehicle distance

Trips (n=1,615)	Median km/trip
Car	10.3
Motorcycle	9.8
Walking	0.45

Current rail user access-egress modal share:





Rail journey (n=89)	Median
Origin-destination	15.1 km
Access/egress by vehicle	5.7 km
Interconnectivity ratio	0.42

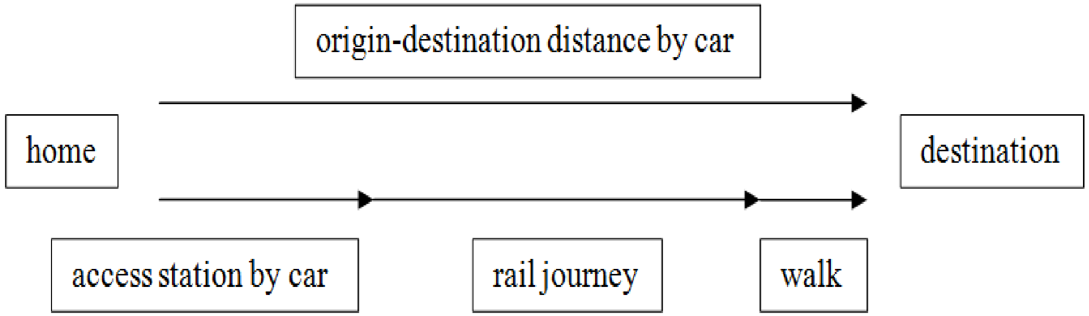
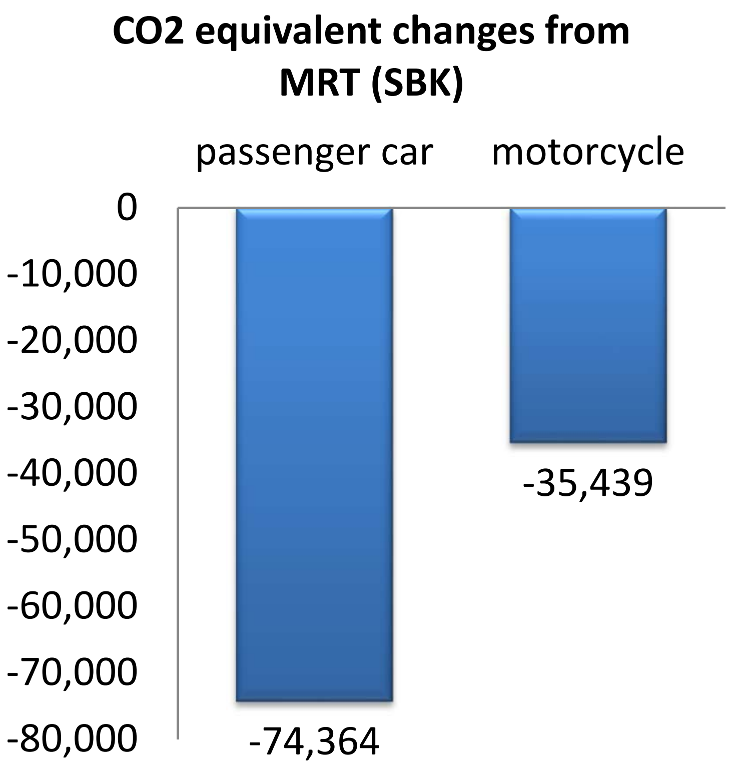


Figure 3.3 An example of rail journey using car to access rail station



Changes to CO2 equivalent (tons/yr)

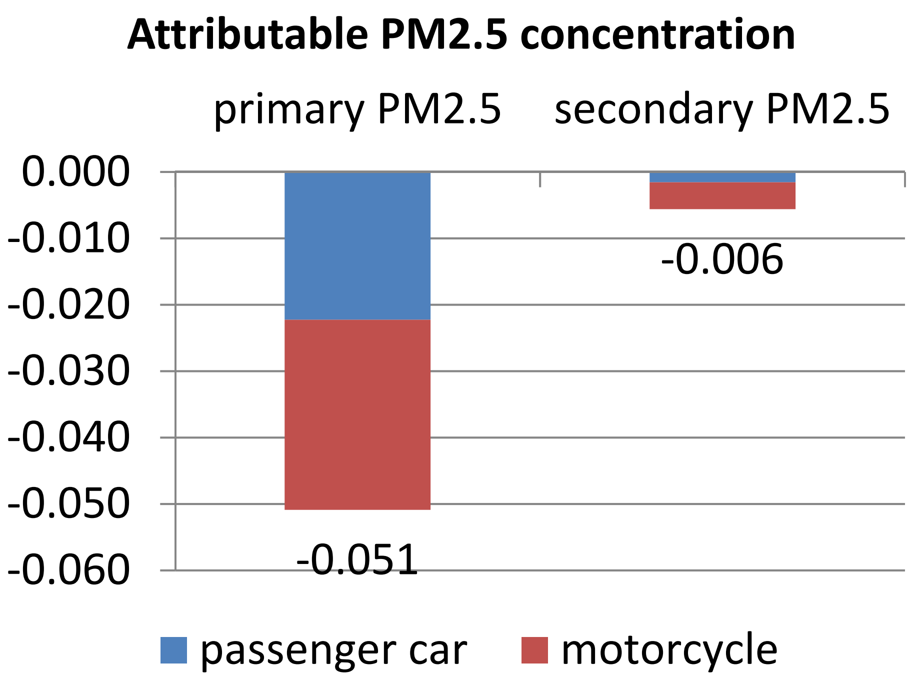
	Car	Motorcycle	Total
Line haul	**-114,848**	**-38,306**	**-153,155**
Acc-egress	40,484	2,867	43,353
Net total	**-74,364**	**-35,439**	**-109,802**

- MRT (SBK) would reduce **153,000 tons CO2 eq (2.8%)** of transport emissions in Greater KL.
- The access-egress using private vehicle **offset 28%** of the carbon savings.
- Cars would contribute 93% of the CO2 reduction in line haul but also 98% CO2 increase in access-egress trips.

Air quality

Emissions of air pollutants for MRT SBK (kg/day)

	PM2.5 (kg/day)	PM2.5 precursors (kg/day)			PM2.5 (µg/m3)
		SO2	NOx	NH3	
Passenger car	13	1	89	11	0.024
Motorcycle	**17**	**0**	**467**	**2**	**0.033**
Total	31	1	556	12	0.056



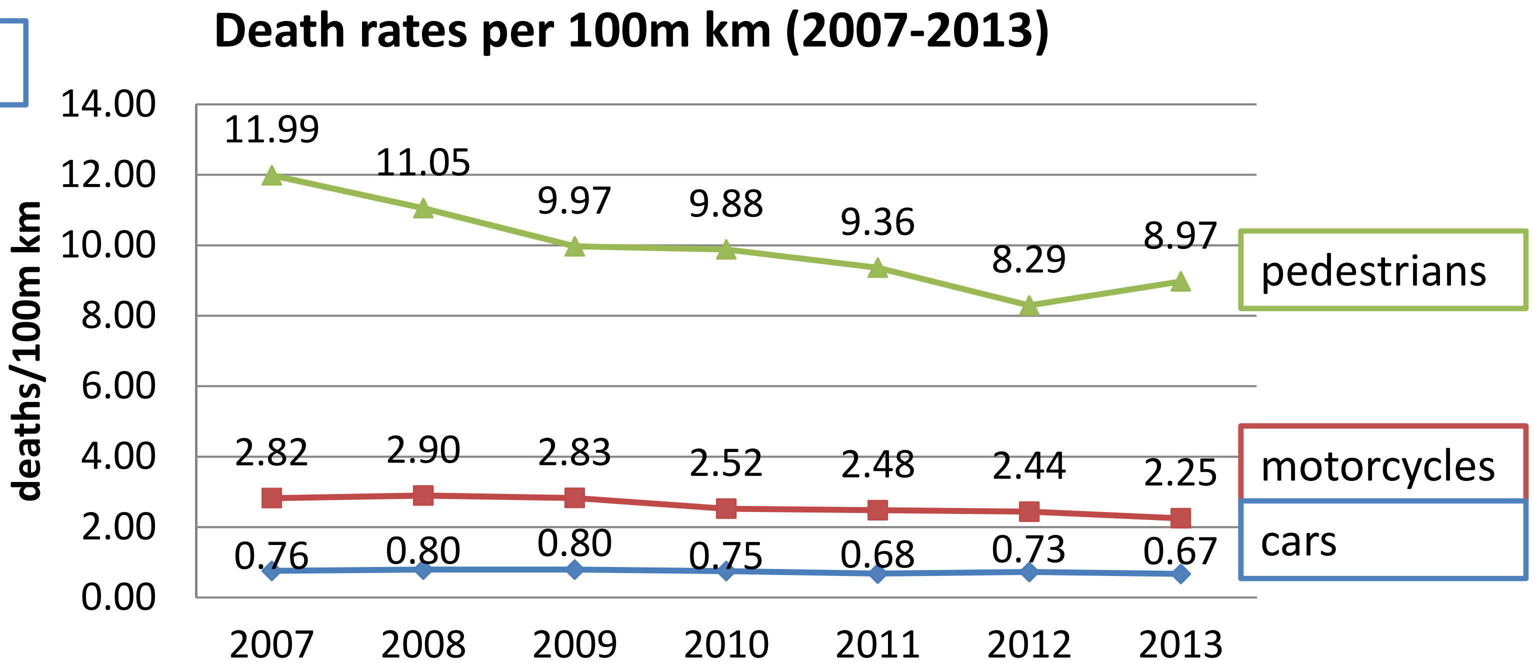
- **Motorcycle** contributed 58% of direct PM2.5 and 85% NOx emissions.
- In total, 0.06 µg/m3 (0.02%) ambient PM2.5 would be reduced.
- NOx (highest emission) contributed 8% PM2.5 concentration reduction.

Attributable death and burden of diseases from PM2.5 concentration reduction

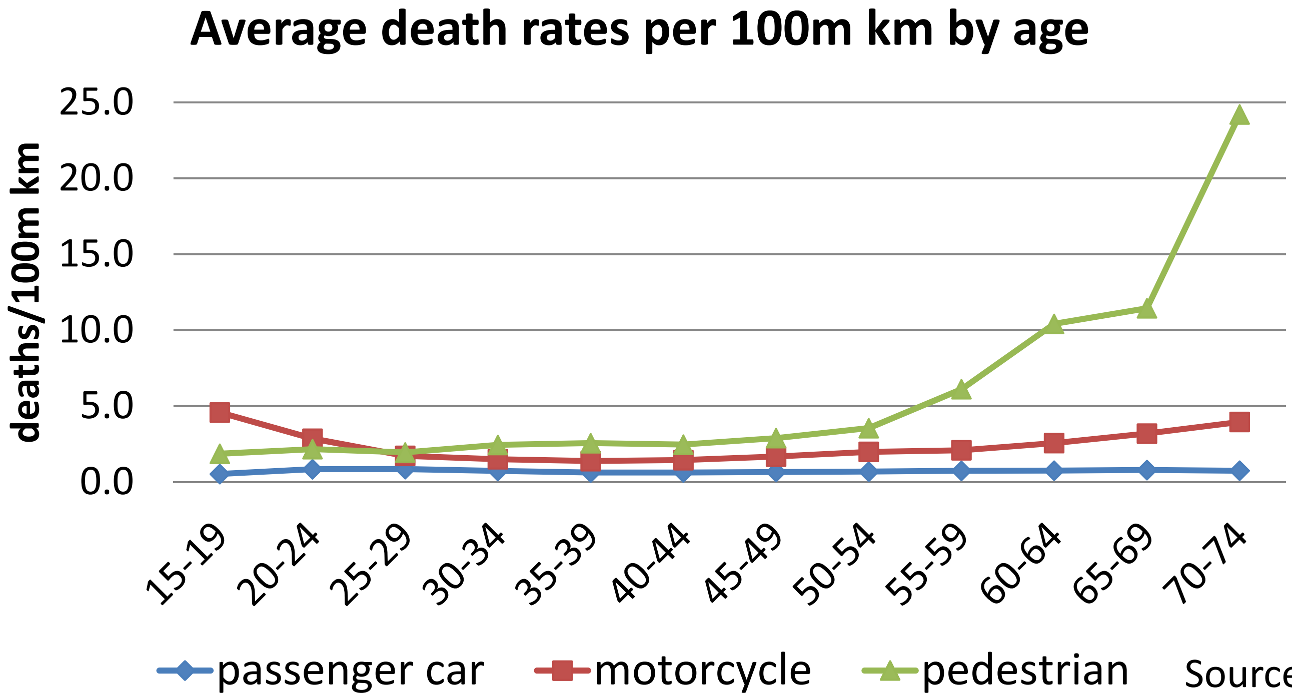
Related diseases (age)	Death	%	YLL	%	YLD	%	DALYs	%
ARI (<5)	0.00	0.02	-0.03	0.02	-0.01	0.02	-0.04	0.02
Cardiovascular diseases (>30)	**-1.01**	**0.05**	**-19.50**	**0.05**	**-0.93**	**0.05**	**-20.44**	**0.05**
Respiratory diseases (>30)	-0.42	0.05	-7.50	0.05	-3.81	0.05	-11.31	0.05
Lung cancer (>30)	**-0.12**	**0.10**	**-2.65**	**0.08**	**-0.03**	**0.09**	**-2.68**	**0.08**
Total	**-1.56**		-29.71		-4.79		**-34.50**	

ARI: Acute respiratory diseases
Cardiovascular diseases included hypertensive heart disease (HHD), ischemic heart disease (IHD), cerebrovascular disease (CVD), inflammatory heart diseases;
Respiratory diseases included lower respiratory disease, upper respiratory disease, chronic obstructive pulmonary disease (COPD), stroke and other respiratory diseases.

Traffic injury

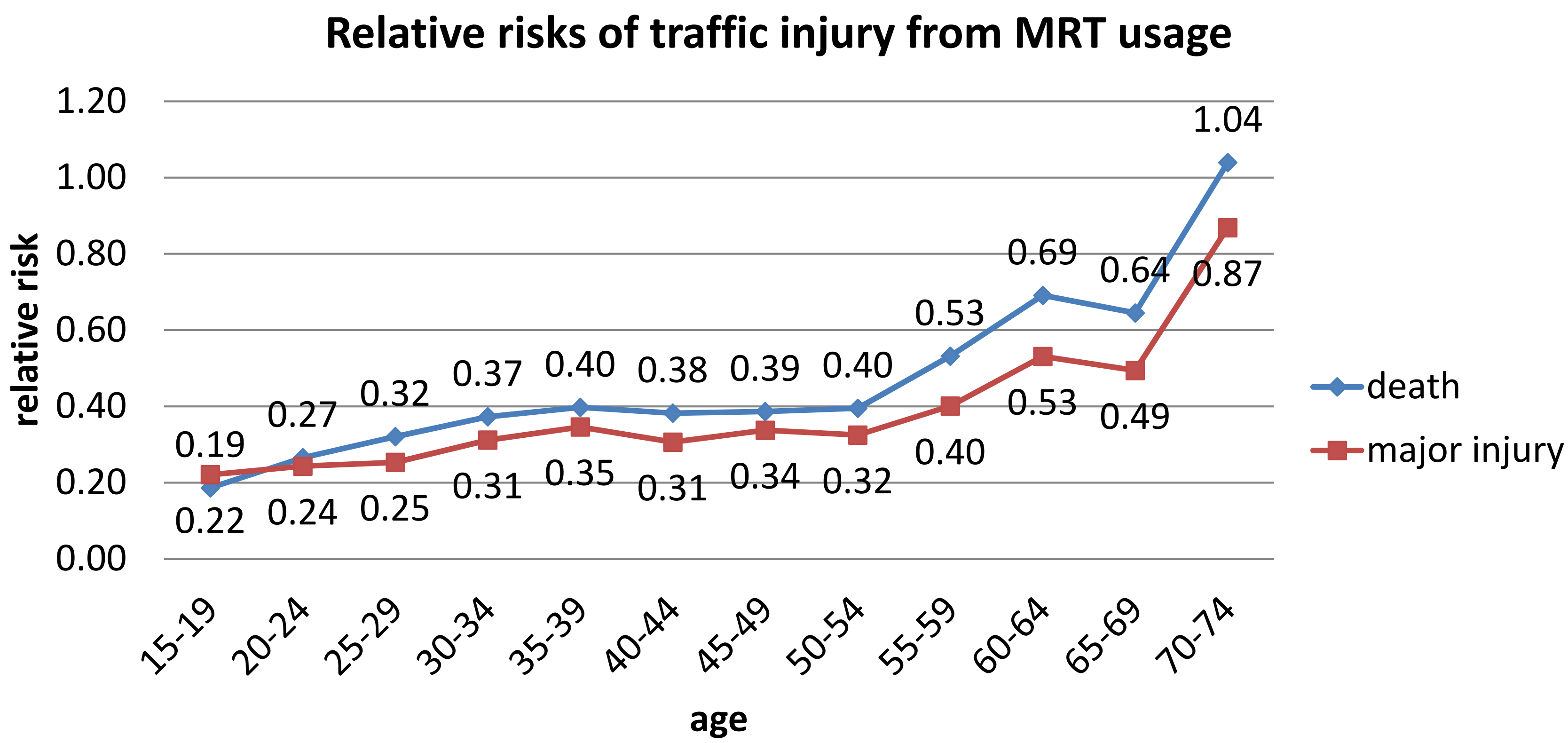


Source: MIROS



Source: MIROS

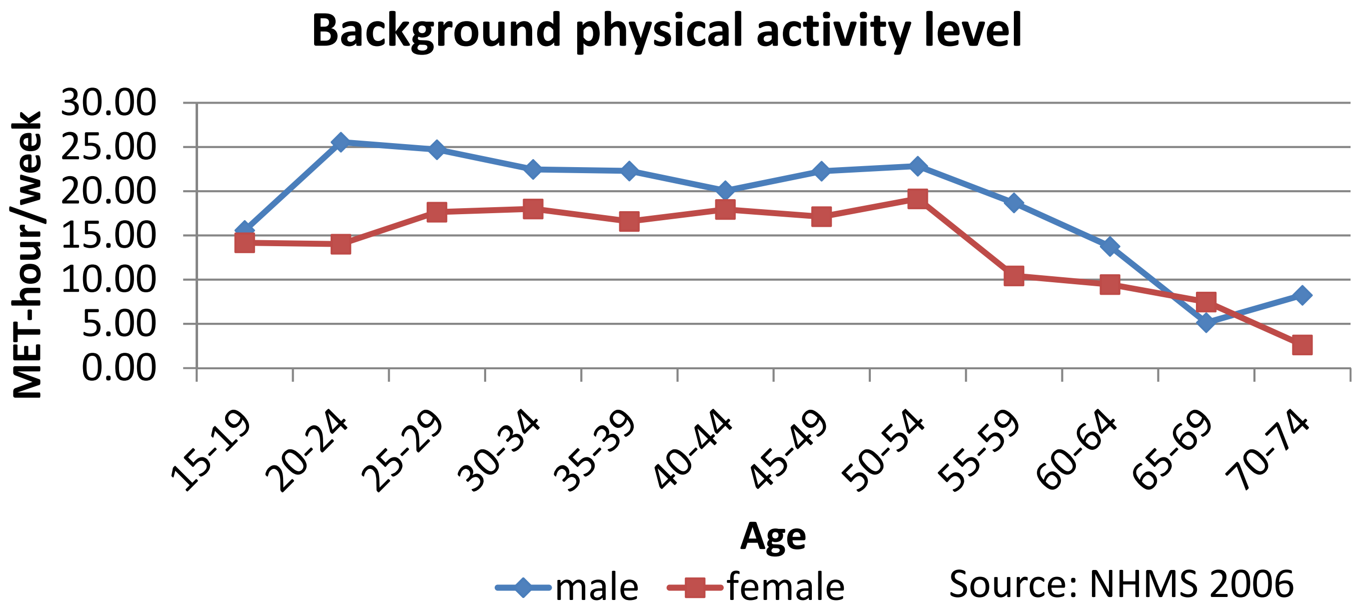
- High death rates remained in the younger age groups especially among motorcyclists.
- Older population had higher pedestrian death rate.

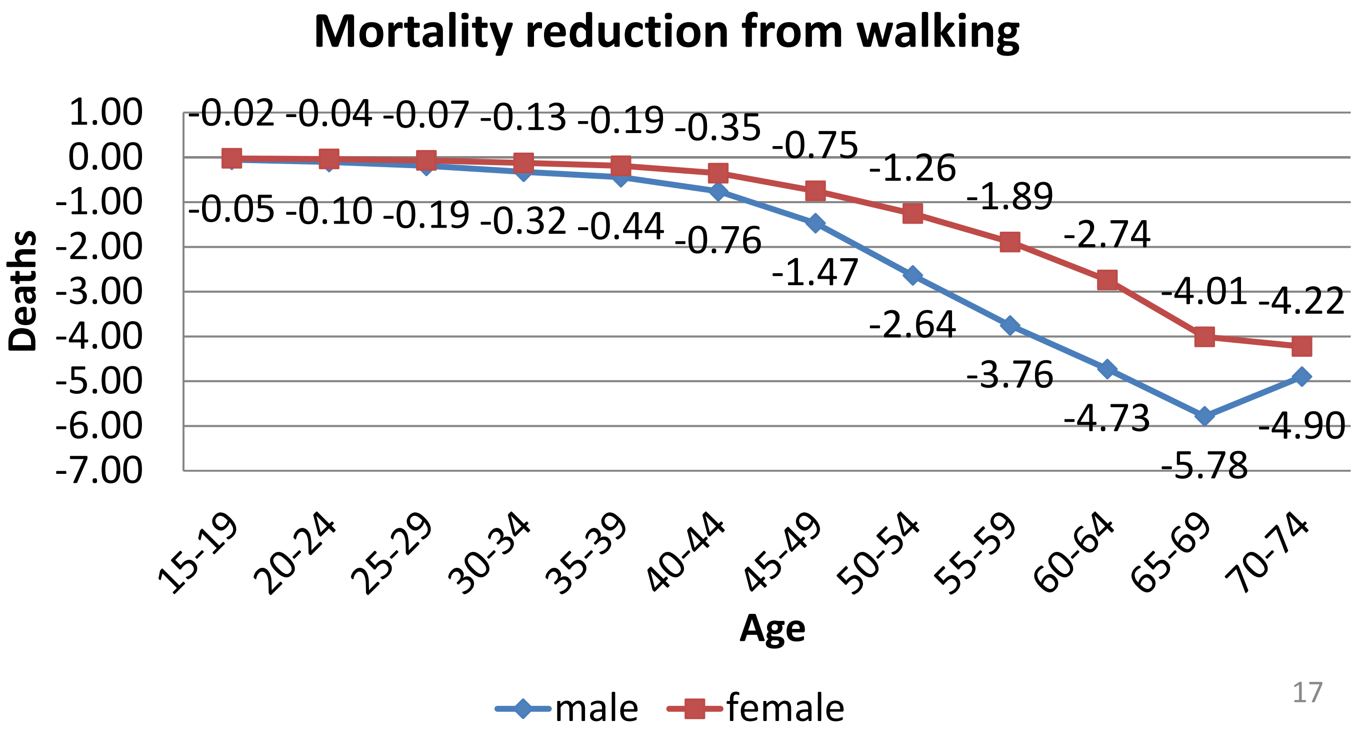


- The largest traffic injury benefits would be from the younger age groups.
- There would also be a 4% increase in risk for age group 70-74.

Age	**Changes from using MRT**			
	Death	**YLL**	**YLD**	**DALYs**
15-29	-22	-1,415	-235	-1,650
30-59	-14	-589	-479	-1,068
60-74	-4	-95	-43	-138
Total	**-40**	-2,099	-757	**-2,856**

Physical activity





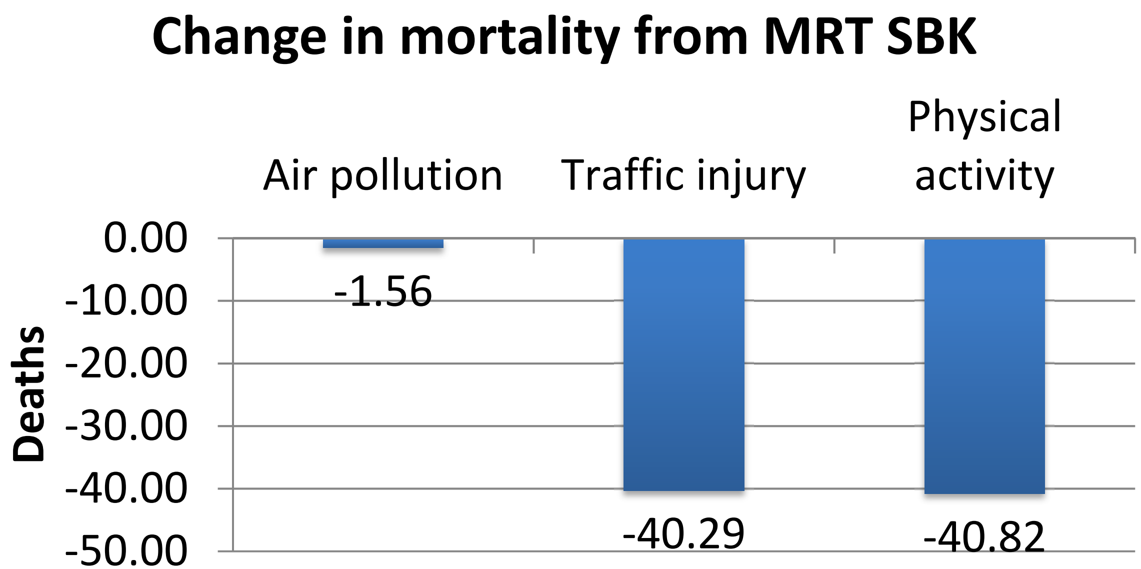
- Premature mortality reduced with increased age.
- This corresponded to the curvilinear exposure response function.

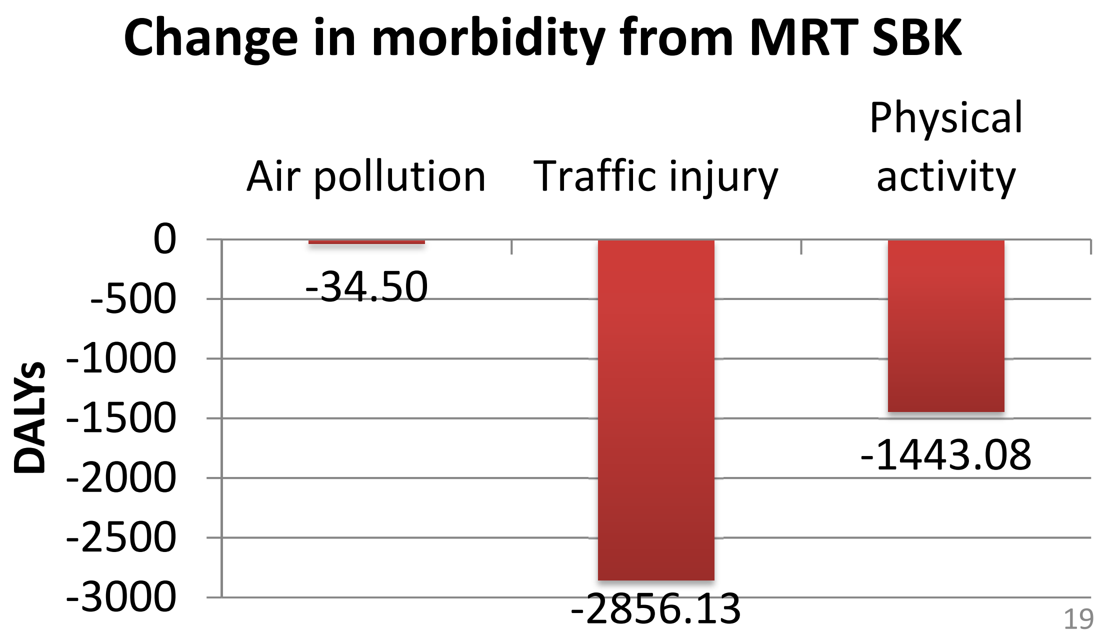
Attributable burden of physical activity from MRT (SBK)

Related diseases	Death	%	YLL	%	YLD	%	DALYs	%
Breast cancer	-1	-2	-21	-2	-1	-2	-22	-2
Colon cancer	-1	-5	-20	-5	-1	-5	-21	-5
Dementia	0	-11	-1	-10	-7	-10	-8	-10
Depression	**0**	**0**	**0**	**0**	**-234**	**-6**	**-234**	**-6**
Diabetes	-4	-12	-101	-12	-77	-12	-178	-12
Hypertensive heart disease	-1	-13	-37	-13	-1	-13	-39	-13
Ischemic heart disease	**-23**	**-13**	**-597**	**-13**	**-30**	**-13**	**-627**	**-13**
Cerebrovascular disease	-11	-13	-297	-13	-18	-13	-314	-13
Total	**-41**	-12	-1074	-12	-369	-8	**-1,443**	-10

Summary

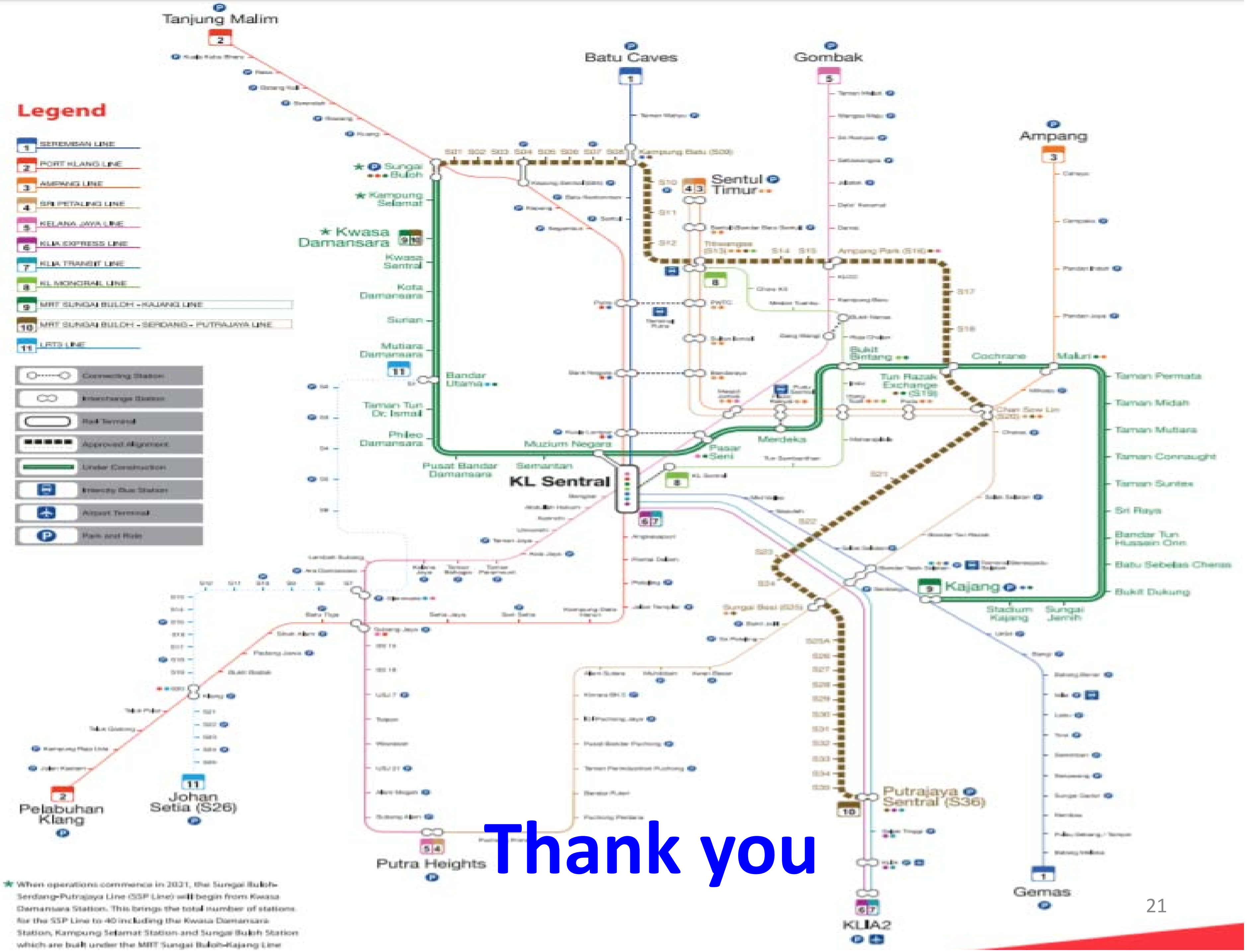
- ➢Traffic injury and physical activity would reduce equal number of premature mortality.
- ➢The largest number of DALYs avoided would be from traffic injury.
- ➢Overall, 83 deaths and 4,334 DALYs would be avoided from MRT(SBK).





Conclusion

- The MRT infrastructure could contribute to the reduction of GHG emissions from private motor transport in the city.
- Reduced traffic injuries and increased physical activity from MRT usage would bring equally important health co-benefits to the population with marginal air quality improvement.
- Alternative transport mode should be encouraged in the access of station (esp. home end) to maximize the emission reduction and health benefits.
- In future planning for MRT alignment and station location, the potential for health co-benefits could be taken into consideration.



Legend
SEREMBAN LINE
PORT KLANG LINE
AMPANG LINE
SRI PETALING LINE
KELANA JAYA LINE
KLIA EXPRESS LINE
KLIA TRANSIT LINE
KL MONORAIL LINE
MRT SUNGAI BULOH - KAJANG LINE
MRT SUNGAI BULOH - SERDANG - PUTRAJAYA LINE
LRT3 LINE
Tanjung Malim
Batu Caves
Gombak
Ampang
Sungai Buloh
Kampung Selamat
Kwasa Damansara
Kwasa Sentral
Kota Damansara
Surian
Mutiara Damansara
Bandar Utama
Taman Tun Dr. Ismail
Phileo Damansara
Pusat Bandar Damansara
Semantan
Muzium Negara
Pasar Seni
Merdeka
Sentul Timur
Bukit Bintang
Tun Razak Exchange (S19)
Cochrane
Maluri
Chan Sow Lin (S20)
Taman Permata
Taman Midah
Taman Mutiara
Taman Connaught
Taman Suntex
Sri Raya
Bandar Tun Hussein Onn
Batu Sebelas Cheras
Bukit Dukung
Kajang
Stadium Kajang
Sungai Jernih
KL Sentral
Putrajaya Sentral (S36)
Putra Heights
Pelabuhan Klang
Johan Setia (S26)
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Thank you