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The potential for active commuting by bicycle and its possible effects on public health

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ABSTRACT

Introduction: The World Health Organization (WHO) has concluded that physical inactivity and overweight/obesity are the world's fourth and fifth leading risk factors for non-communicable diseases, respectively. This article investigates the potential for active commuting by bicycle in Scania county, southern Sweden, and its possible impact on public health. Physical inactivity is a growing problem on both an individual and a societal level.

Method, setting and population: A complete statistical survey and geographic analysis has been carried out based on data concerning the home and work addresses of the entire working population in the county of Scania, Sweden as of the end of 2014. This data set includes a total of 575,959 individuals.

Results: Approximately 27.9% of the population can reach their workplace by a 15-min bicycle commute, while 47.2% can reach their workplace in 30 min. It is possible to achieve a 47.2% modal share for active transport in Scania if all individuals within cycling distance of work choose to commute by bicycle. If that were to happen, 19.2% of the working population would meet the WHO's global health recommendations just through their commutes.

Conclusion: The results demonstrate that the spatial distribution of homes and workplaces in Scania is conducive to increasing the mode share for active transport through well-designed physical environments and transport systems that prioritise physical activity.

1. Introduction

Physical inactivity is a growing problem on both an individual and a societal level. The World Health Organization (WHO) has concluded that physical inactivity and overweight/obesity are the world's fourth and fifth leading risk factors for non-communicable diseases, respectively. Together they are responsible for 11% of the annual deaths globally (World Health Organization, 2009).

Physical activity equivalent to at least 30 min of brisk walking every day has been shown to not only reduce the risk of overweight/obesity but also to reduce the risk for a large number non-communicable diseases, including coronary heart disease, high blood pressure, and diabetes (Reiner et al., 2013). New findings suggest that lower levels of daily physical activity also have a positive effect on health, but the WHO's global recommendations on physical activity for health are still the most accepted recommendations (Warburton and Bredin, 2017). The WHO's global recommendations on physical activity for health recommend 150 min per week of moderate physical activity or 75 min per week of vigorous physical activity to stay healthy (World Health Organization, 2010). Over the course of a typical 5-day working week, this corresponds to 30 min of moderate physical activity or 15 min of vigorous physical

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activity each day. Despite the limited level of physically activity needed, only two-thirds of the population in Sweden and 120 other countries meet the global health recommendations (Axelsen et al., 2012), (Hallal et al., 2012). Oja et al. (2011) have also reinforced the positive health effects of cycling be research. Moreover, an increased level of cycling often also leads to more physical activity, which has a positive impact on peoples' health (Nieuwenhuijsen et al., 2019). Research ha also shown that commuting by bicycle has great health benefits, even if those benefits are related to the risk of pollution along the way, if more cycling means a reduction in motorised traffic (de Hartog et al., 2010). Another study showed that inb three dirrefent European cities the positive effects of cycling in terms of health, environment and comfort outreach the effect of driving or using public transport, which supports the fact that increased cycling in the Region of Scania would have many positive effects (Woods and Masthoff, 2017).

The WHO recommends that urban planners encourage physical activity through the design of urban spaces and to promote active transportation as a serious alternative to motorised options as a possible way to address the problem of an increasingly inactive population (World Health Organization Regional Office for Europe, 2016). For this urban planning-based approach to be successful, it is important to recognise that the domains in which people are physically active have changed. Technical innovations both at and outside of the workplace have made it possible to substantially reduce the amount of physical effort necessary to perform everyday tasks. Occupational physical activity, which previously constituted the main source of an individual's physical activity, is decreasing while recreational physical activity is increasing (Hallal et al., 2012).

Promoting bicycling in general and bicycle commuting in particular has been shown to have the potential to increase the levels of physical activity among the population (Celis-Morales et al., 2017) (Gerrard et al., 2012) (Oja et al., 2011). Bicycle commuting also has several advantages over other modes of transport. For example, bicycling does not contribute to any direct CO^2 emissions or noise pollution. It is also one of the fastest modes of transport in many cities as it is possible to avoid traffic jams (Heinen et al., 2010).

Despite the many positive effects on both the societal and individual level, bicycling has remained a marginalised mode of transport (Koglin and Rye, 2014). However, in recent years there has been a renewed interest from governments and researchers on how to encourage more people to bike (Heinen et al., 2010). One body, which has shown an increased interest in promoting bicycling, is the Scania Regional Council in Sweden. In 2014, the Council decided to develop one of the first regional bicycling strategies in Sweden in order to encourage active commuting and public health in the region, the plan was decided on in 2017 (Region Skåne, 2017). The strategy was to add the bicycle to the already existing strategies focusing on public transport, freight traffic and car usage.

Scania is one of the most densely populated regions in Sweden with 1.3 million inhabitants spread over 10,393 km^2. Most of the inhabitants live in Malmö (336,000), Helsingborg (144,000), Lund (121,000), Kristianstad (84,000) and Hässleholm (52,000) (Statistiska centralbyrån, 2018). As the southernmost province of Sweden, the winters are generally mild and the landscape is in most parts quite flat. Thus, the conditions for bicycle commuting are favourable by Nordic standards. Nevertheless, of all the commutes, only 17% are made by bicycle, compared to 59% by car, 18% by public transport and 5% by walking (Ullberg and Wahl, 2014).

The large percentage of passive commuting is a challenge for the region. According to research on the working population in Scania there is a strong correlation between overweight/obesity and the mode of transport used to commute to work. Commuting by active modes of transport such as walking or cycling has a strong negative correlation with overweight/obesity, while the opposite is true for commuting by car (Lindström, 2008). For the policy makers and urban planners in Scania and elsewhere, it is important to recognise the potential for daily physical activity during a person's commute to work and to include it as a perspective in transport planning. However, to create an urban environment designed around prioritising active transport is not easy. There is little research on that the potential of bicycling strategies actually producing the desired benefits (Handy et al., 2014), apart from a seemingly positive relationship between having a comprehensive network of bike paths and higher levels of bicycling (Buehler and Dill, 2015). However, without some knowledge of the desired route choices of cyclist on a wider scale, it is hard to direct the efforts to where they could have the best effects (Broach et al., 2012).

The aim of this study is to look at the potential for active commuting by bicycle in Scania. Furthermore, the research carried out for this article wants to find out what health effects increased bicycle commuting might have and to investing in what geography, the potential for bicycle commuting is largest.

The following three questions are to be answered:

1. How many people can reach their workplace by a 15 or 30-min bicycle journey? And how many individuals could meet the WHO's global health recommendations by switching to active commuting habits?
2. Along which routes would the commutes occur if everyone who lives within a biking distance were to bicycle to work?
3. What is the full potential for active transport in Scania?

2. Method

The distance between the home and workplace addresses was analysed using a network analysis tool in a geographical information system (GIS). The Network analysis was preformed to find the shortest path between each person's home and workplace addresses. To perform the task the following input data was used:

2.1. The home and workplace addresses

An address register from Statistics Sweden (SCB) containing the work and home addresses for the entire working population in Scania. The data contains information about 575,959 individuals and are current as of the end of 2014.Due to privacy regulations,

SCB does not provide the exact coordinates to an individual's home and work address. Instead, the location data is offered as a raster grid with a resolution of 100 m to which the data is assigned. This data is not publicly available and was bought directly from SCB.

2.2. The road network accessible to bicycles

The analysis used the current road and bike path network in the National Road Database (NVDB) provided by the Swedish Transport Administration (Trafikverket, 2016a). Running the Network analysis to find the shortest route it was assumed that it is possible to bike wherever it is legal (excluding pavements and motorways).

2.3. Average cycling speed

The mean cycling speed used in the calculation is set at 16 km/h. This is the speed for which the municipal cycling infrastructure is designed in Sweden (Wallberg and Hårdstedt, 2010).

2.4. Maximum travel time distance

The maximum one-way commuting duration is set at 30 min based on a comprehensive study whose aim is to define a realistic travel distance for a cycling commute (Johansson et al., 2017).

2.5. Health impact

When knowing the potential for active commuting, it is possible to calculate how many could reach the recommended levels of physical activity. Adults should be active at least 150 min per week at a moderately intense level or 75 min per week at a vigorous level in order to stay healthy (World Health Organization, 2010). An activity of moderate intensity is said to be between 3.0 and 5.9 Metabolic Equivalent of Task (MET) while one of vigorous intensity is 6.0 MET or greater. Cycling at 16 km/h is an activity of moderate intensity and is measured at 4.0 to 6.8 MET (Ainsworth et al., 2011). Thus, at least 15 min of commuting by bicycle to work and 15 min from work implies that a person will reach the recommended level of physical activity for the day.

3. Analysis and results

3.1. Potential for biking to work

Table 1 shows how many individuals are able to cycle from their home address to their work address in a given time. The results indicate that about 27.9% or 160,693 of the 575,959 individuals can reach their workplace within 15 min by bicycle. Almost half of the working population in Scania, 47.2%, can reach their workplace if the maximum travel time is increased to 30 min.

Fig. 1 is a heat-map that shows where the commuter trips up to 30 min would occur, assuming that all individuals were to choose the shortest path. Moreover, the heat map shows all of the origin-destination pairs and is a good approximation for a likely commuting route. This is necessary information for planners trying to increase the bicycling share in Scania or elseward, so that they can focus their efforts to where the potential is highest. The map indicates that most commutes would occur within the more densely populated areas in Scania, mainly around the urban centres. When looking at the potential of bicycle trips above, it becomes rather clear that the larger cities in Scania could increase their share of cycling.

In regard to exposure to air pollution Quin et al. (2019) conclude in a systematic literature review that physical activity in a high polluted environment could lead to certain health problems, such as increased risk of the immune function. However, such risk only occur in highly polluted environment. The region of Scania can generally not be seen as such an area. Furthermore, Tainio et al. (2016) conclude that air pollution might reduce the health benefits of cycling, especially in urban environments that are highly polluted. Nevertheless, the also conclude that cycling in urban areas outweigh the risks of air pollution. Moreover, Tainio et al. (2016) also argue that if car driving is replaced by cycling the health benefits would be even higher.

3.2. Potential health impact

To stay healthy, adults between 18 and 64, should stay active for at least 150 min per week (World Health Organization, 2019). A single journey to work must therefore be at least 15 min. This implies that 160,693 individuals should be excluded from the results since they could cycle to work within less than 15 min. If all other individuals who can cycle to work within 30 min were to commute by bicycle, then 111,160 persons would reach or exceed the recommended level of daily physical activity. It corresponds to 19.2% of

Table 1
Indicates how many individuals are able to cycle from their home address to their work address in a given time.

Travel time	5 min	10 min	15 min	20 min	25 min	30 min	35 min	40 min	45 min	50 min	55 min	60 min
% of the working population	5.00	16.7	27.9	36.2	42.4	47.2	51.1	54.4	57.5	60.1	62.4	64.7
Number of people	28798	96185	160693	208497	244207	271853	294315	313322	331176	346151	359398	372646

Fig. 1. Shows where the commuter trips up to 30 min would occur if all individuals were to choose the shortest path.

the working population. According to the research on cycling and health benefits (Gerrard et al., 2012) the public health in the Region of Scania could be improved, if the potential could be utilised.

4. Discussion

In the latest reported figures concerning active commuting to work in Scania, published in 2013, active transport accounts for 22% of all commutes to work, with 5% of the population walking to work and 17% cycling to work. The modal share for other commutes is 58% by car, 19% by public transport, and 2% of the trips are categorised as other (Ullberg and Wahl, 2014).

As demonstrated above, it is possible to achieve a 47.2% modal split for active transport in Scania if all individuals within cycling distance to work choose to commute by bicycle. Realising the full potential would mean an increase in active commuting (walking and biking) of 145,142 commuters, from 126,711 in 2013 to 271,853.

4.1. Strength and limitations

The potential for active commuting by bicycle in Scania should be regarded as an outcome from the analysis above that indicate what can theoretically be achieved. The figures are based on the assumptions that everyone can and wants to cycle to work, is always looking to take the shortest route, maintains an average cycling speed of 16 km/h, and is willing to cycle for up of 30 min one-way to and from work. What is not taken into account are the other factors that affect one's behaviour, including but not limited to personal preferences, socio-economic factors, culture and traditions, habits as well as the physical structure of cities and the quality of the transport system (Handy, 2005). The reason for not taking into account the quality of the transport system is because the distance between one's home and workplace, we believe, is more of a premise than the infrastructure that is combining them. It is in other words more difficult for planners to have an influence on where people live and work, than it is for them to improve the infrastructure in-between. Bike friendly infrastructure is in this regard more of a mean to reach the potential than a premise deciding the potential. To establish an idea of what parts of the road network that is good enough for cycling is also beyond the scope of this article. It is a sever task, that cannot be solved only by study variables available from NVDB. The data available for NVDB are limited, not fully updated and most important because this data say very little about the actual experience of the road when biking. Any such analysis must therefore be complemented by the involvement of both local planners and local residents to be accurate enough. This process has however been made easier because of the method used in this article, as it will help to focus on the areas where the highest potential might be.

The theoretical model used to calculate the potential is limited by the available data. The data provided by Statistics Sweden detailing the working population contains no information about each individual's personal characteristics, thus, it is not possible to model cycling speed based on for example, age, gender, or physical condition. Neither is it possible to determine speed from the (NVDB) as it only contains speed limits for cars (Trafikverket, 2016a). Therefore, a realistic speed for bicycle commuting needed to be estimated from other data. A cycling speed of 15 km/h is used by the Swedish Transport Administration to conduct cost-benefit analyses for investments in bicycle infrastructure (Trafikverket, 2016b). In the handbook for planning municipal bicycle infrastructure, the average cycling speed is instead estimated to be 16 km/h (Wallberg and Hårdstedt, 2010). Furthermore, the most

comprehensive study on cycling speed thus far conducted by the Swedish National Road and Transport Research Institute found that the actual cycling speeds tend to vary between just below 16 km/h to 25 km/h, depending mainly on bicycle type, traffic flows, topography, and personal characteristics of the cyclists themselves (Eriksson et al., 2017). For the purposes of this study, 16 km/h is selected as the mean speed for biking because it is a speed that most individuals can achieve and because very few cyclists have been shown to travel at 15 km/h or less. Moreover, although Eriksson et al. (2017) suggests a cycling speed of 20 km/h, it is unclear whether all of the individuals in this study could achieve that speed due to the limited data available concerning their physical conditions. A cycling speed in the low-end of the suggested range compensates for potential hilly conditions, poor biking infrastructure, large traffic volumes, and weather, which are all factors that have been shown to decrease cycling speed, as well as also ensuring that cyclists of all abilities could be included (Eriksson et al., 2017). More research is needed to establish what could be regarded as reasonable cycle speeds for different groups of people in different environments.

It is difficult to determine the number of people who are not capable of cycling to work even though they live within cycling distance. There are numerous possible preconditions and personal circumstances, which could prohibit one's ability to cycle. Some of these are possible to overcome, such as not having access to a bicycle or not having been taught how to ride a bicycle, and so on. Others cannot be expected to cycle due to physical limitations. Although there are no regional statistics that quantify the number of people in the Scanian working population who are affected by physical disabilities, approximately 13% of the working population at the national level has some form of disability as of 2014 and 2015. Of those, 60% reported that their disability affects their ability to work. Nevertheless, it is not possible to definitively conclude from the available data how these disabilities may affect the possibility to commute to work by active transport (Statistics Sweden, 2016). However, if it is assumed that 13% of the Scanian population is not physically capable commuting by bicycle even though they live within cycling distance to work, then the adjusted potential for active commuting is 41.1%. Realising that full potential would mean an increase in active commuting (walking and biking) by 110,008 commuters from 126,711 in 2013 to 236,719.

There other ways to calculate health benefits then the method used in this article. The Health economic assessment tools (HEAT) for walking and for cycling is a tool developed by the World Health Organization. HEAT estimates the value of reduced mortality that results from specified amounts of walking or cycling and it can also take into account the health effects from road crashes and air pollution, and effects on carbon emissions. However, the tool has shown not to be compatible with this type study. The outcomes calculated by HEAT tool are based changes in the modal share. Thus, in order to estimate what would occur if the full potential for biking in Scania was realised it is also necessary to know what other journeys those cycling trips would replace (Kahlmeier et al., 2017). That is however not possible, since there are no accurate estimates to rely on when the theoretical potential is as large as showed in this article.

Finally, the introduction of electrically assisted bikes could potentially affect the MET figures and therefore the number of people reaching the health goals; however, few or no articles have yet sought to study such a relationship (Fishman and Cherry, 2016). This study is limited to examine the potential for cycling and its consequent health effects for bicycles without electric assistance.

5. Conclusion

The results demonstrate that the spatial distribution of homes and workplaces in Scania is conducive to increasing the mode share for active transport through well-designed physical environments and transport systems that prioritise physical activity. Approximately 27.9% of the Scanian population, or 160,693 individuals, can reach their workplace by a 15-min bicycle commute. The corresponding figure for a 30-min bicycle commute is 47.2%, or 271,853 individuals.

To meet the WHO's global health recommendations by switching to active commuting habits the commute must be longer than a 15 min bicycle ride one way. Otherwise, it will presumably not make up the recommended 30 min a day. In Scania 19.2% of the working population, 111,160 persons, would meet the WHO's global health recommendations by switching to active commuting habits. If everyone who lives within a biking distance of their workplace were to bicycle, most of these commutes would take place within the more densely populated areas (the urban centres) in Scania as illustrated by Fig. 1.

It is possible to achieve a 47.2% modal share for active transport in Scania, if all individuals within cycling distance to work choose to commute by bicycle. Realising the full potential would mean an increase in active commuting (walking and biking) of 145,142 commuters from 126,711 in 2013 to 271,853. In order to achieve such a shift in the mode share, the municipalities and cities in Scania have to develop their bicycle infrastructure and work closely with the Region of Scania, so that comprehensive bicycle networks around the region and within the municipalities can be created.

Conflict of interest

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