Application

2018-00047 **Malmqvist, Ebba** **Brg1757**

Information about applicant

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Project site: Laboratoriemedicin, Lund 314200

Information about application

Call name: Housing policy for Social Sustainability 2017

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Focus: Targeted call

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Project title (english): Densifying the cities without increased environmental health burden-is it attainable?

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Project end: 2020-12-31

Review panel applied for: Brg1757

Classification code: 30303. Occupational Health and Environmental Health, 10507. Physical Geography, 10502. Environmental Sciences (social aspects to be 507)

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Keywords: densifiering, hälsokostnader, luftföroreningar, buller, gröna miljöer

Funds applied for

Year:	2018	2019	2020
Amount:	1,631,121	1,976,257	1,761,018

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Basic information

Number of project years*

3

Calculated project time*

2018-01-01 - 2020-12-31

Project title (Swedish)*

Andas frisk luft och höra fågelsång i en tät stad-hur kommer vi dit?

Project title (English)*

Densifying the cities without increased environmental health burden-is it attainable?

Popular scientific description (Swedish, max 4 500 characters)*

Denna utlysning sätter människan och människans möjligheter till en god boendemiljö i centrum. Idag bor de flesta svenskar i städer och en förtätning av staden är och har varit nödvändig för att minska bostadsbristen. Att förtäta en stad har många fördelar, så som ökat antal bostäder, minskade transportsträckor och att slippa använda bördig jordbruksmark för nya bostäder. Samtidigt finns det en hälsorisk med detta som sällan syns i diskussionerna, trots att föroreningar i svenska städer leder till tusentals förtida dödsfall årligen. Genom förtätning bor fler människor i områden där halter av luftföroreningar och buller idag kan orsaka hälsoproblem och där hälsofrämjande gröna miljöer minskar. I vissa städer såsom Malmö finns också en miljöorättvisa i att bostadsområden där socialt redan utsatta familjer och enskilda bor har byggts vid motorvägar och värmeverk där markpriserna är lägre. För att kunna bygga en stad som är tät men som inte därmed leder till hälsopåverkan måste forskare och det omgivande samhället samarbeta redan på planeringsstadiet.

I FN's nya hållbarhetsmål finns en klar vision "The New Urban Agenda" om att samhället tillsammans med forskare ska jobba för att städer planeras så att hälsokonsekvenserna minimeras. I detta projekt ämnar vi att hitta tvärvetenskapliga lösningar tillsammans med ett flertal kommuner och företag för en stadsplanering med människans hälsa i fokus. Projektets resultat får på så sätt en direkt positiv inverkan på allmänhetens tillgång till ren miljö, och en förbättrad hälsa och livskvalitet.

Vi kommer att tillsammans med kommuner, konsultfirmor och byggindustrin identifiera relevanta förtätningsplaner och beräkna vad de olika planerna får för hälsokostnader jämfört med om planerna inte införs. Vi kommer dessutom att komma med utvärderade och förbättrade planeringsåtgärder och tekniska lösningar. Detta kräver ett tvärvetenskapligt förhållningsätt med experter inom många fält.

Forskning på effekterna av luftföroreningar, buller och gröna miljöer har pågått i Skåne i minst ett decennium. Det är dags att kunskapen kommer ut på ett lättillgängligt och lättförståeligt sett i form av hälsokostnader och att kunskapen bidrar till en förtätad men frisk stad. En medvetenhet om att den fysiska miljön påverkar folkhälsan är en grundförutsättning för en hälsofrämjande planering, för att kunna välja mellan olika beslut behövs en dessutom en beräkning av vilken hälsokostnad de olika förslagen ger. Särskilt fokus kommer att ligga på att väga in hur redan känsliga grupper, såsom barn, gravida kvinnor och boende i socioekonomiskt utsatta områden, påverkas av förtätning. Vi kommer också att utföra hälsokostnadsberäkningar och direkta mätningar av luft och buller för att kunna utvärdera tekniska lösningar såsom att placera fler fönster mot innergårdar, ljudisolering, eller hastighetsbegränsningar. Beräkningarna kan sedan ligga till grund för evidensbaserade val för myndigheter och byggindustrin.

Eftersom detta projekt till stor del är beroende av en fungerande kommunikation mellan forskarvärlden och det omliggande samhället (byggföretag, konsultfirmor och kommuner) så är kommunikation en viktig del av detta projekt. Vi jobbar därför tvärvetenskapligt där vi, förutom teknik och medicin, också har miljövetenskapliga kommunikationsexperter som redan har stor erfarenhet att jobba med de involverade samhällsaktörerna. Genom en rad workshops och intervjuer kommer vi säkerställa att vi jobbar med relevanta planer och att vi forskare presenterar kunskap på ett tillgängligt och användbart sett.

Detta projekt kommer att beräkna hälsokostnader relaterade till den miljöpåverkan som olika planer på förtätning skulle kunna leda till i ett samarbete mellan forskare, kommuner, konsultfirmor och byggindustrin. De evidensbaserade planerna och lösningarna kommer att bidra till en förtätad stad som är både hälsosam och hållbar.

Abstract (Swedish, max 1 500 characters)*

Att förtäta en stad har många fördelar, så som ökat antal bostäder, minskade transportsträckor och att slippa använda bördig jordbruksmark för nya bostäder. Men förtätning kan också leda till ökade hälsokostnader eftersom fler bor i områden med höga luftföroreningar och buller, och att grönområden i staden minskar. För att kunna bygga en stad som är tät men som inte därmed leder till hälsopåverkan måste forskare och det omgivande samhället samarbeta nära redan på planeringsstadiet.

Detta projekt kommer att kvantifiera hälsokostnader relaterade till den miljöpåverkan som olika planer på förtätning skulle kunna leda till i ett samarbete mellan forskare, kommuner, regionen och industrin. Projektet kommer också att leverera olika kostnadseffektiva förbättringsförslag på planer och byggnadstekniska lösningar för att minska hälsokostnaderna. Särskilt fokus kommer att ligga på att väga in hur redan känsliga grupper, såsom barn, gravida kvinnor och boende i socioekonomiskt utsatta områden, påverkas av förtätning. De evidensbaserade planerna och lösningarna kommer att bidra till en förtätad stad som är både hälsosam och hållbar.

Abstract (English, max 1 500 characters)*

Densifying a city has positive impact by providing adequate housing, lowering of transportation needs and reducing needs of using arable land for housing. On the other hand, densifying a city have often shown to lead to unwanted health costs by exposing a larger proportion of the population to air pollution and noise, and by reducing urban green areas. In order to create a both dense and healthy city, with low environmental health impact, the scientific community and stakeholders need to work closely together in the planning of high-density areas (housing and infrastructure).

This project will quantify the health effects of status quo and of a set of densification scenarios. Different ways of densifying a city will be explored, to define easily attainable pollution reduction strategies targeting the larger municipal planning level as well as the more detailed scale (detail plan level). The work will be conducted in close cooperation with stakeholders from involved municipalities and the region. We will also propose new cost-effective and suitable mitigation techniques for plans and building techniques in a dialogue with the construction industry. We will especially consider the environmental health effects on vulnerable groups such as children, pregnant women, and population in low-income urban districts. Developing such evidence based pollution reduction strategies is essential to ensure future healthy dense cities that promotes a long-term social sustainability of housing.

Summary of how gender or other critical perspectives are integrated into the project (English, max 1 500 characters)*

There exists an environmental justice perspective in most urban settings, which is important to address: air pollution levels, access to green areas, and the possibility to sleep without noise disturbance from rail and roads- important health determinants - are differing based on in which area of a city you live. In addition, the daily inhaled air pollution dose, noise disturbance perception and possibility to access green areas vary with age and/or gender [1-3]. We will have a clear gender and age perspective in the proposed project, and we will stratify all main analyses by age and gender. The present study area involve cities with extensive socio-economic challenges and disparities. There are clear environmental injustice perspectives when it comes to i.e. air pollution in the study area, with higher levels in areas with more socioeconomic challenges [4]. Still the environmental health burden perspective is lacking in most urban housing plans. It is of concern that the scientific community makes the environmental health burden, including the injustice perspective, of plans and policies more easily accessible and understandable to decision-makers. We will include socio-economic status on an area-level in the analyses. We further aim of reducing environmental injustice by creating tools to reduce environmental health burden for all inhabitants. This is important in order to achieve the goals of adequate housing for all without increasing environmental health burden.

Research programme

Specific aims and objectives of the proposed project and a background description containing an overview of the research area. Describe also here how the purpose of the project and the issues examined relate to gender or other critical perspectives. (max 7 000 characters)*

Densifying of cities have positive environmental impact by lowering transportation needs and reducing need of arable land for housing. On the other hand, densifying a city can lead to unwanted health costs by exposing a larger proportion of the population to air pollution and noise, and by reducing urban green space. In order to create a both dense and healthy city this dilemma needs to be properly addressed by knowledge-based urban planning.

Purpose: to create evidence-based support in the planning of high-density areas (housing and infrastructure) in order to achieve low environmental health impact.

The overall goals are:

1) Making health costs of different housing plans and policies visible with a special focus on environmental injustice (socio-economy, age and gender)

2) Suggesting new cost-effective, evidence-based and easily attainable pollution reduction strategies, together with stakeholders from municipalities, region, and industry.

Background: The fact that air pollutants increase the risk of morbidity and mortality even at relatively low pollutant concentrations is indisputable, even air pollution levels in Swedish cities are estimated to cause 5000 premature deaths yearly [1]. Studies in the proposed area have found air pollution effects focusing on morbidity, with increasing health care visits due to respiratory symptoms, and increased risk of asthma and stroke [2-4]. Pregnant women and their fetus are especially susceptible and we have found air pollution effects such as lower birth weight, preeclampsia and gestational diabetes in the proposed area [5, 6]. Access to green areas are beneficial for, and increase, outdoor activities, physical exercise and thus health [7]. Green space relatively close to housing areas is especially important for the young and elderly population that are often confined to the closest neighbourhood for outdoor activities. Females is another group whose access to green area can be restricted due to perception of safety [7]. Traffic noise causes annoyance and disturbs daily activities such as rest and sleep [8]. Females and groups already suffering from economic stress seemed especially vulnerable to noise related hypertension or stress [8]. In many cities, including the proposed area, there are also environmental injustice perspectives e.g. levels of air pollutants are higher in areas or part of areas with a higher proportion of socioeconomic challenges [9].

In Sweden, it is evident that air quality policies have managed to reduce air pollution, but many areas are still on the verge of reaching the air quality standards, and current levels in cities in Scania are still within those levels where health effects have been identified [10, 11]. The problem of today is that most low hanging fruits, in regards to mitigation, have already been picked and in-transported air pollution levels are bound to increase[12]. Densification of residential areas, and especially the building of new houses in areas with already high density of infrastructure for transport and energy (e.g. roads, railways, heating appliances), will expose a larger proportion of population to detrimental levels of air pollution and noise. Densification by using urban green areas for building houses, on the other hand, will lower the population's access to urban green areas. Despite the scientific knowledge of the links between pollutants, health risks and socio-economic differences, there seems to be a gap between the scientific knowledge provided and the extent to which this knowledge is translates into urban planning . Sometimes there is an interest dilemma between stakeholders regarding health and housing shortage, e.g. lasts years alterations in the Plan and Building act in relation noise levels (daily average noise level at a building's facade in new homes can be 60 decibels, instead of 55).

United Nation has recently presented their New Urban Agenda highlighting the need of local authorities working together with researchers in creating a sustainable city [14]. Researchers recently presented the Lancet-commission and proposed the following; pollution mitigation needs to be integrated into development planning, and health effects of policies and plans needs to be made visible by calculating health costs [15]. One of the great challenges presented is to ensure that high-income countries continue to reduce pollution as every single step to mitigate population exposure has great benefits for human health and save the society money. The economic costs of such prevention, e.g. air pollution mitigation, have been shown to be paid back 30 times the invested money [15].

This project acknowledge these findings and propositions by leading health experts. However, our FORMAS-funded project ARIEL has shown that development and implementation of research based plans and mitigation measures requires a wide societal dialogue, where decision makers, scientists, and a variety of other societal actors must participate. The framework DPSIR (Driver, Pressure, State, Impact, Response), has previously been used successfully in bridging gaps between environmental management and other sectors by e.g. United Nations Environment Program (UNEP) and European Environmental Agency (EEA) [16]. Previous examples of integrated assessment by DPSIR as a support to design strategies for mitigation of air pollution, such as Rains model to protect against acidification and the ExternE project to highlight hidden costs of energy, have laid basis for modern European air quality legislation [17]. The success of DPSIR framework has been by clarifying the role of society, different economic sectors and public administration in managing common environmental problems; here exposure to pollutants, and creating bridges between science and society [16]. The original DPSIR framework can, in relation to environmental health impact, be improved by adding a refinement of the "Pressure-State-Impact" part of the framework [18]. This has successfully been done recently with an adaption to **DPSEEA Driver, Pressure, State, Exposure, Effect** and **Action** [19]. WHO supports the use of Health Impact Assessments [HIA] as a mean of assessing the **Effect** of policies, plans and projects to supporting decision-makers in their choices, between alternative **Actions**, to prevent disease/injury and to actively promote health [20].

We suggest a project, where a multi-disciplinary team of scientists will work closely together with region, selected municipalities, and industries in Scania using a well-established framework, DPSEEA, to quantify health effects of densification plans and suggest mitigation procedures. The project is in line with the call by contributing new knowledge to support the development of socially sustainable housing policy.

References (max 4 000 characters)

12. Gustafsson, M., et al., *Quantification of population exposure to NO2, PM2.5 and PM10 and estimated health impacts in Sweden 2010*. 2014, Swedish Environmental Research Institute IVL.
13. Taj, T., et al., *Short-Term Associations between Air Pollution Concentrations and Respiratory Health-Comparing Primary Health Care Visits, Hospital Admissions, and Emergency Department Visits in a Multi-Municipality Study.* Int J Environ Res Public Health, 2017. **14**(6).
14. Oudin, A., B. Forsberg, and K. Jakobsson, *Air pollution and stroke.* Epidemiology, 2012. **23**(3): p. 505-6.
15. Lindgren, A., et al., *Adult asthma and traffic exposure at residential address, workplace address, and self-reported daily time outdoor in traffic.* BMC Public Health, 2010. **10**: p. 716.
16. Malmqvist, E., et al., *Fetal growth and air pollution - A study on ultrasound and birth measures.* Environ Res, 2017. **152**: p. 73-80.
17. Malmqvist, E., et al., *Gestational diabetes and preeclampsia in association with air pollution at levels below current air quality guidelines.* Environ Health Perspect, 2013. **121**(4): p. 488-93.
18. Weimann, H., et al., *Perception of safety is a prerequisite for the association between neighbourhood green qualities and physical activity.* Health Place, 2017. **45**: p. 124-130.
19. Bjork, J., et al., *Road traffic noise in southern Sweden and its relation to annoyance, disturbance of daily activities and health.* Scand J Work Environ Health, 2006. **32**(5): p. 392-401.
20. Stroh, E., et al., *Are associations between socio-economic characteristics and exposure to air pollution a question of study area size?* Int J Health Geogr, 2005. **4**: p. 30.
21. Spanne, M., et al., *Luften i Malmö 2016.* 2017, Malmö City Environmental Department.
22. Johansson, L., S. Gustafsson, and A. Arvin, *Luftkvalitet med fokus på kvävedioxid och partiklar PM10 i Skånes kommuner 2014*. 2015, Malmö City Environmental Department.
23. Orru, H., K.L. Ebi, and B. Forsberg, *The Interplay of Climate Change and Air Pollution on Health.* Curr Environ Health Rep, 2017. **4**(4): p. 504-513.
24. Sallis, J.F., et al., *Use of science to guide city planning policy and practice: how to achieve healthy and sustainable future cities.* Lancet, 2016. **388**(10062): p. 2936-2947.
25. United Nations, *New Urban Agenda 71/256*. 2017.
26. Landrigan, P.J., et al., *The Lancet Commission on pollution and health.* The Lancet, 2017.
27. García-Onetti, J., M.E.G. Scherer, and J.M. Barragán, *Integrated and ecosystemic approaches for bridging the gap between environmental management and port management.* Journal of Environmental Management, 2018. **206**(Supplement C): p. 615-624.
28. Bartonova, A. and M. Jovasevic-Stojanovic, *INTEGRATED ASSESSMENT AND MANAGEMENT OF AMBIENT PARTICULATE MATTER*, 2012. **18**(4): p. 605-615.
29. Svarstad, H., et al., *Discursive biases of the environmental research framework DPSIR.* Land Use Policy, 2008. **25**(1): p. 116-125.
30. Lebret, E., *Integrated Environmental Health Impact Assessment for Risk Governance Purposes; Across What Do We Integrate?* International Journal of Environmental Research and Public Health, 2016. **13**(1): p. 71.
31. WHO. *Health Impact Assessment (HIA)*. 2010 [cited 2017 2017-11-23]; Available from: http://www.who.int/hia/en/.
32. Reed, M.S., et al., *Participatory scenario development for environmental management: a methodological framework illustrated with experience from the UK uplands.* J Environ Manage, 2013. **128**: p. 345-62.
33. Stroh, E., et al., *Measured and modeled personal and environmental NO2 exposure.* Popul Health Metr, 2012. **10**(1): p. 10.
34. Hertz-Picciotto, *Epidemiology and quantitative risk assessment: a bridge from science to policy.* Am J Public Health, 1995. **85**(4): p. 484-91.
35. Fann, N., et al., *Improving the linkages between air pollution epidemiology and quantitative risk assessment.* Environ Health Perspect, 2011. **119**(12): p. 1671-5.
36. WHO, *Health risks of air pollution in Europe – HRAPIE.* 2013: Copenhagen.
37. Hanninen, O., et al., *Environmental burden of disease in Europe: assessing nine risk factors in six countries.* Environ Health Perspect, 2014. **122**(5): p. 439-46.

Description of the project including a summary of the structure, theory, methods, performance and a plan for scientific deliverables. Describe how gender or other critical perspectives are integrated into the execution of the project, for example in terms of methods selected, theory etc. (max 15 000 characters)*

Study area and stakeholders

Three municipalities in Scania, Southern Sweden; Malmö, Lund, Helsingborg.

We will use already established network of actors engaged in the collaboration network *Urban areas and their surrounding in sustainable land use* including regional actors in the physical planning area such as the municipalities mentioned above as well as consultant firms and building companies. Building companies such as Riksbyggen (involved in network), SKANSKA; NCC and PEAB (contacts) are responsible for planning the placement and the surrounding of new houses and infrastructure. Consultant firms is an important actor as they perform analysis for municipalities and building companies in relation to several of the issues dealt with in this application.

Method

We will use the causal framework **DPSEEA** to structure the multi-disciplinary, science/society research collaboration. Specific methods are described under each step of the framework (as work-packages). **DPSEEA** is a causal framework for describing the interactions between society and the environment. **Drivers** are activities that are the reason for environmental problems: here the densification of cities. **Pressures** are the physical properties causing the problems: here the emissions of air pollutants and noise, and lack of green areas in dense residential areas. **State** is the state of the environment caused by the pressure: here quality of air and noise, and distance to, size and number of green areas. The state leads to **Exposure**. **Effect** of the Exposure is the health costs. **Actions** are the mitigation of the problem; here the policies, city plans and building placements.

Work-package 1, Drivers: PI: Ebba Lisberg Jensen and Johanna Alkan Olsson

Drivers are activities that are the reasons for environmental problems: here the densification of cities which has so far lead to an increased part of the population exposed to high levels of noise and air pollution (**Driver**: transport) and less space for green areas (**Driver**: infrastructure and buildings). The aim of this work-package is to identify relevant densification strategies.

In this work-package, we work together with officers at environment and city planning departments (though a series of interviews) at the involved municipalities to assess which densification-related policies or city plans we should evaluate related to the drivers; transport and land use for housing and infrastructure. We also work together with the industry to explore mitigation choices (through a series of interviews). Analysis of policy documents and text are done through text analysis by researchers and the results are used as input to two workshops. Relevant densification strategies are identified through two workshops where we in workshop 1 discuss the general development trends with municipal officials and representatives from industry. In workshop 2 we discuss the results from the policy document analysis with local stakeholders to collect their perception on densification strategies.

Work-package 2, Pressures: PI: Ebba Malmqvist and Emilie Stroh (emissions), Johanna Alkan Olsson (workshops with stakeholders)

Pressures are the physical properties causing the problems: here the emissions of air pollutants and noise and lack of green areas in residential areas. The aim of this work-package is to identify how different densification strategies, scenarios, affect these physical properties.

To assess air pollution levels we use an existing emission database from Scania Air Quality Board. We will calculate noise from road and railway from the same database and for green areas, we will use input from satellite imaging, RapidEye. We will calculate a business-as-usual scenario as well as a set of other scenarios, were we incorporate different changes that would occur if adopting a certain densification strategy (identified in work package 1). The scenarios will be developed together with involved stakeholders using participatory scenario making [21]. These scenarios will then be used for assessments in the following framework steps (work-packages) as well. To ensure that the scenarios are relevant we will arrange two workshops with local authorities to develop the scenarios and to ensure local relevance. Workshop 1 will be about the general scope of scenarios (emissions, noice green space), and in workshop 2 we will validate detailed scenarios developed by scientists. The scenarios will be built on changes in emissions and noise parameters related to speed limits, building of speed bumps, adding and removing roads available for traffic and noise barriers (inducing changes in emissions and noise levels in emission database). For the green areas, we will use the Geographical Information System (GIS)-program ArcGIS to implement different changes related to access to green areas. We will work with the stakeholders for co-creation of urban densification scenarios. Workshop 1 will be about the general scope of scenarios (emissions, noice green space), and in workshop 2 we will validate detailed scenarios developed by scientists.

Work-package 3, Exposure: PI: Emilie Stroh (GIS-modelling) and Christina Isaxon (measurements)

Exposure is the state of the environment in the residential areas, where people are affected, here quality of air, level of noise, and green areas affected by the physical properties identified in Pressure (Work-package 2). The aim of this work-package is to quantify the air pollution and noise levels and access to green areas in residential areas and assess how those levels changes by both densification strategies and mitigation strategies.

Based on the emission database we use a modified Gaussian Dispersion model (AERMOD, US EPA) to disperse the air pollution emissions to the affected populations. The dispersion model will give an output in nitrogen oxides and particles of different types and size fractions (soot, PM2.5 and PM10) with high spatial (up to 50m) and temporal (hourly) resolution. Modelled levels and measured levels has good correlation[22]. Dispersion of airborne pollutants can be adapted by e.g. changing building placements. We use SoundPlan to assess the dispersion of noise into residential areas and how dispersion of noise can be adapted by e.g. noise barriers and building placement.

Green areas and their accessibilities can be modelled using GIS (geographical information system) and present land use satellite imaging (Rapid Eye) of the city/cities together with residential data, and thus study the populations and population groups (children, youngsters, elderlies, low socioeconomic groups) possibilities/proximities to these areas (distance, accessibility, size and number). It is also possible to study the "population load" or pressure on each green area depending on its size and use as well as the type and size of the residential area it is supposed to cover. We can evaluate and quantify planned changes in the city plan for the green environments by implementing these changes into GIS and apply them in HIA.

To be able to quantify the importance of various mitigation strategies in terms of air quality and noise levels, measurements of both airborne particles (soot, PM2.5, PM10) and noise will be conducted in addition to modelling. Measurements will be conducted to validate basic assumptions of the models, but also to study potential outcomes of suggested changes in plans and policies. The measurements will be conducted by portable instruments for time-resolved mass concentration (DustTrak DRX) and time-resolved number concentration (Philips NanoTracer, measures particles smaller than 300 nm). We spend about 85% of our time indoors (at home and at work) indicating that how indoor air quality and noise levels can be affected by various interventions is of special interest. Questions which can be answered by measurements are e. g. comparisons of how much less we are exposed to air pollution and noise if we design residential housing with bedrooms facing the back of the houses instead of facing the street, and if this is more cost- and health-effective than lowering the number of vehicles and/or their speed at said street. The quantitative effects of vegetation, e g trees along the road, or green facades, on air quality and noise levels indoors can also be evaluated by measurements.

Work-package 4, Effects: PI: Anna Oudin and Ebba Malmqvist

Effects of the Exposure (Work-package 3) are the health costs (negative and positive) associated with both densification and mitigation strategies. The aim of this work-package is to quantify the health costs, using Health Impact Assessment [HIA], of densification and mitigation strategies.

Whilst epidemiologists often study the risk of a disease in the presence of exposure relative to the risk of a disease in the absence of exposure, a risk assessor on the other hand often asks; how many excess cases of disease will occur in a population of a certain size due to exposure at a certain dose level? [23]. HIA generally apply a health impact function combining a risk estimates from the epidemiology literature that relate hypothesized air quality (noise or green area) changes to a population at risk [24].

The Swedish national registers provide data on baseline number of outcomes, for example county specific baseline disease prevalence in the population available in Statistics Database from Swedish National Board of Health and Welfare. Data on baseline prevalence of diseases on a municipal level have to be applied for with the register holders. Given that this is group-level data, this is usually a simple procedure. All Swedes has a unique personal identification number ("personnummer") and data from different registers can be linked together with this unique number. Data on individual residential geocodes, age and sex will be retrieved from Region Skåne (a self-governing administrative region responsible for health care). Exposure levels and exposure reductions will be individually assessed at each individual's residential geo-coded location. Age and sex are important both for assessing appropriate health outcomes in relevant populations but will also be used to assess if certain policies affect gender and age groups differently. In order to capture if policies will affect groups with differing SES differently, we will perform HIA within and between socioeconomic group level areas by using Small Areas for Market Statistics (SAMS)-areas created by Statistics Sweden. We will primarily use risk estimates recommended by WHO HRAPIE [25] for air pollution and by European Environmental Burden of Disease for Noise and green areas [26]. For some outcomes, we will add risk estimates from other studies in sensitivity analysis.

Work-package 5, Actions: PI: Johanna Alkan-Olsson, Christina Isaxon and Ebba Malmqvist

Actions are the mitigation of the problem; here the mitigation of policies, city plans, building and infrastructure placements and characteristics. The aim of this work-package is to communicate, discuss and evaluate the implementation feasibilities of the mitigation strategies and their effects on health in different groups of the society identified in the work-packages described above, with the relevant stakeholders.

We will, in close cooperation with the stakeholders and based on the assessment in previous work-packages;

1) evaluate current and planned densification plans and policies in relation to their health costs (identified in work-package 4) and suggest improvements. This will provide an adequate information base to policy-makers community and business to support a sustainable urban planning.

2) suggest evidence-based, related to health costs (Work-package 4) and measured levels (Work-package 3), improvements in building characteristics (e.g. placement of windows, noise insulation) and building placements in microenvironments.

Hypothesis testing

We have successfully tested the hypothesis of HIA in a pilot study in the FORMAS funded project ARIEL by evaluating transportation policies in Malmö. Under the project ARIEL we have also studied the knowledge transfer from scientific results to urban planning and identified several potential communication errors (e.g. lack of time and resources to incorporate epidemiological findings on environmental health). We will acknowledge these findings by translating the epidemiological findings (with enough evidence reviewed by WHO) into health burden (e.g. number of asthma cases). As examples of different technological and planning mitigation strategies, we have previously shown that placement of bedroom windows to a more quiet side can reduce noise disturbance [8] and the possibility for females to use green areas for physical activity is depending on safety designs [7].

Timetable

Task DPSEEA	Time table	Responsible (PI highlighted)	Specific tasks	Stakeholder involvement
Driver	2018-08-01- 2018-12-31	**Ebba Lisberg Jensen** **Johanna Alkan-Olsson** Ebba Malmqvist	Discussion with stakeholders to identify relevant plans/policies	Two workshops
Pressure	Already in place	**Emilie Stroh** **Ebba Malmqvist** **Johanna Alkan-Olsson**	Data extraction and co-creation of urban densification scenarios	Two workshops
Exposure	2019-01-01- 2019-12-31 2020-06-01- 2021-06-01	**Emilie Stroh** **Christina Isaxon** Ebba Malmqvist	Modelling plans/policies with existing databases	In discussion with stakeholders
Effect	2020-01-01- 2021-12-31	**Ebba Malmqvist** **Anna Oudin** Kristina Jakobsson	Health Impact Assessments of plans/policies and mitigation efforts	Presented to stakeholders
Action	2020-06-01- 2021-12-31	**Christina Isaxon** **Ebba Lisberg Jensen** **Johanna Alkan-Olsson** Ebba Malmqvist Kristina Jakobsson	Evaluate and suggest improvements to plans/policies and building characteristics and placements	Two workshops

Scientific dissemination

We will pursue publication in leading international peer-reviewed open-access journals. We plan to publish at least five articles; one methodological article, one covering the knowledge-transfer from science to stakeholders, two covering the health impact assessments of plans and polices with specific input on gender and SES and two articles on actions (one on the plan/policy impact and one on technological building solutions). We also plan to disseminate results at national and international conferences on sustainable urban planning, urban governance, urban air quality, and environmental health.

National and international co-operation

This is a joint project of Lund University and Malmö University with support from Gothenburg University (to ensure generalizability). We are currently involved in several international cooperations; including projects regarding pollution, health and urban development with researchers at UCLA, IS Global, Adis Ababa University, Copenhagen University and Danish Cancer Society. We have been involved in the EU funded ESCAPE project and the EU Interreg project ReproUnion. In relation to placement of green and blue green space we will interact with the project Urban Nature (FORMAS) and Naturvation (H2020).

Description of the potential societal benefits of the project, focussed communication efforts and interaction with stakeholders. Describe here the groups that the research is relevant for, how these will potentially be included in the research and how the results of the project will be communicated. Describe also how the potential impact of the research will affect different groups in society. (max 8 000 tecken)*

Societal value

Environmental health research has been conducted for several decades; it is of uttermost concern, for both the policy makers, and public health, that this knowledge is implemented into society and made comprehensible and accessible. In Sweden alone, approximately 5000 people each year will have a premature death due to air pollution if we do not manage to reduce the levels [1]. The importance of the possibility to access green areas and to sleep without noise disturbance are also important determinants of health, which need to be taken into consideration in urban planning. If the research society can help to not only quantify but also find solutions to reduce the environmental health burden we have all to gain.

The challenges of cities to provide safe air quality, noise levels and access to green areas as well as the need for densifying the cities due to increasing transportation needs and competing land use needs is huge. At the same time, cities are facing increasing populations and expanding commuting regions. When developing urban areas, it is essential to ensure that all segments of society will benefit from this development. There are several recent findings that shows a contrary pathway, especially in relation to the potential negative effects of densification. Urban planners need to decide how to move forward in order to lower the environmental health burden identified in our study area, including the environmental injustices, but challenges and competing interests are great. This project will assess the health effects of status quo as well as a set of scenarios exploring different ways of densifying a city to define easily attainable pollution reduction strategies targeting the larger municipal planning level as well as the more detailed scale (detail plan level) together with stakeholders from involved municipalities and the region. The proposed study will be also suggest new cost-effective and suitable mitigation techniques for plans and building techniques for the construction industry. We will especially consider the effects on vulnerable groups. The development of such evidence based pollution reduction strategies is essential to ensure the development of healthy dense cities that promotes a long-term social sustainability of housing. To ensure the relevance for local stakeholders we engage throughout the project in a co learning process by the means of a series of seminars.

Communication with stakeholders

Development and implementation of research based mitigation measures requires a wide societal dialogue, where the decision makers, the scientists and a variety of other societal actors are partners. We will use already established network of actors engaged in the collaboration network *Urban areas and their surrounding in sustainable land use* including over 20 mainly regional actors in the physical planning area such as the municipalities (Malmö, Lund Helsingborg) , building companies (Riksbyggen, SKANSKA, NCC and PEAB) as well as consultancy firms responsible for planning the placement and the surrounding of new houses as well as infrastructure. Although researchers have written this proposal, we came up with the initial idea in a stakeholder meeting and end-users have constantly evaluated the proposal in order for it to fulfill their specific needs. In order for other cities and areas to be able to benefit from this project, we will strive to make the results highly generalizable.

The first communication goal is to quantify the environmental health impact of plans and policies related to housing in general and densification in particular.

The second communication goal is to discuss solutions to the health impact and identify solutions to lower health impact.

Communication process

This will be done by engaging with key stakeholders in a series of workshops that both will serve as dissemination and co-learning opportunities:

- Step Drivers – Two workshops: assessment of relevant policies and policy documents; workshop 1 discuss the general development trends with municipal officials and representatives from industry and workshop 2 discuss the results from the policy document analysis with local stakeholders to collect their perception on densification strategies
- Step Pressures – Two workshops: co-creation of urban densification scenarios. Workshop 1 will be about the general scope of scenarios (emissions, noice green space), and in workshop 2 we will validate detailed scenarios developed by scientists.
- Step Action – Two workshops: development of checklist and strategies for how quantification of health impacts (HIA) of densification plans and possible mitigation strategies can be included in the municipal planning and urban development. Workshop 1 evaluate current and planned densification plans and policies in relation to their health costs and suggested improvements. Workshop 2 suggest evidence-based improvements in building characteristics (e.g. placement of windows, noise insulation) and building placements in microenvironments.

In addition to these workshops the project will arrange two larger seminars in close collaboration with Kommunförbundet which is a part of the network for sustainable land use described above, targeting municipalities in the Scania region and interest organizations (e.g. Astma och Allergiförbundet, Building Industry). The focus of these seminars will be to discuss the checklist and how to develop policy strategies to integrate helth concerns in municipal planning.

We will further present and discuss results and study design at several occasions through already well-established contacts with the Regional air quality board (Skånes Luftvårdsförbund). On a national perspective, we are working closely with Swedish Environmental Protection Agency (Titus Kyrklund and Johan Genberg). We have also partners who can provide valuable input at the Sound Environment Center at Lund University and with landscape architects at SLU, Alnarp. Internationally, we will communicate with Sylvia Medina at the EU-funded project APHEKOM and the European Environmental Agency. Project collaborator is also the Institute for Sustainable Urban Development (ISU). ISU is a joint venture between The City of Malmö and Malmö University, and offers opportunities for debates, seminars and workshops with researchers, policymakers, urban planners and citizens in the Malmö region. We will thus use already well-established platforms for communications with stakeholders. The project will also have a website where we will present the project and result continuously.

The involved researchers are all experienced in communicating research results by various media. Dr. Lisberg Jensen and Dr. Alkan Olsson have been working for the last decade on knowledge transfer between municipalities and research communities. Dr. Isaxon is an experienced researcher in communicating complicating scientific methods and results to the public and is a regular speaker in such events at public libraries, EU parliament, Almedalsveckan, and the Lund University 350 year jubilee. PI Dr. Malmqvist is very interested in the interface between research and policy and the public and have been the board member of the Occupational and Environmental Medicine Popular Science Newsletter (together with Dr. Stroh and Prof. Jakobsson) and been the plenary speaker of events within EU on electric cars (www.great.eu) and Clean Air Coalition. Dr. Malmqvist has also successfully been working with Malmö Municipality in different collaborations (ARIEL and SPIS).