Transportation Research Part A 129 (2019) 306–320

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

Urban form, travel behavior, and travel satisfaction

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ARTICLE INFO

Keywords:
Built environment
Travel satisfaction
Urban form
Commute time
Travel mode
Travel behavior

ABSTRACT

The relationship between the built environment and travel satisfaction has not been adequately explored in previous research. This study examines how urban form affects travel satisfaction using survey and interview data from Oslo metropolitan area, which is a good case for such a study since compact and sprawled urban forms are found to a large extent in the same city region. Results suggest that commute satisfaction as well as leisure travel satisfaction are significantly higher for residents of compact urban neighborhoods than those of sprawled suburbs. The article further focuses on commute satisfaction and finds that this difference is mainly due to differences in (a) trip duration and (b) travel modal split between the two urban form types. (a) Shorter distances to the city center and higher neighborhood densities are associated with significantly lower trip duration to work or education. This lower trip duration experienced by compact-city residents significantly contributes to their higher travel satisfaction. (b) Significant differences in the impact of travel mode on travel satisfaction, controlling for trip duration, are found. From most to least pleasant, travel modes are evaluated as follows: (1) walk, (2) bike and train, (3) bus, tram and metro, and (4) car. These differences contribute to the higher travel satisfaction found in compact neighborhoods, since residents of compact neighborhoods use active travel modes (walking and cycling) to a high extent and the car to a low extent, while suburban residents walk and cycle significantly less and use the car significantly more. Overall, the findings of this study suggest that compact-city policies and car restrictions that are currently applied or planned to be applied in several cities worldwide can have a positive impact on travel satisfaction as they lead to shorter trip durations and more active travel compared with urban sprawl policies.

1. Introduction

Research on factors that can influence travel satisfaction has been focusing mostly on the role of various travel modes (De Vos et al., 2016; Friman et al., 2017; Lancee et al., 2017; St-Louis et al., 2014), but also on congestion (Ettema et al., 2013), trip duration (Morris and Guerra, 2015), weather (St-Louis et al., 2014), perceived safety (Ettema et al. 2012), use of ICTs during travel (Ettema et al., 2012), and on having company when traveling (Lancee et al., 2017). However, little research has been conducted on how urban form, in terms of built environment characteristics such as compactness, density, and distance to city center, affects travel satisfaction.

Investigating this topic can provide important input on the synergies and conflicts of the environmental and social dimensions of urban sustainability. On the one hand, urban form is strongly connected with environmental sustainability as compact urban form is widely regarded as more environmentally friendly than sprawled, car-dependent development (e.g. Newman and Kenworthy, 1999;

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https://doi.org/10.1016/j.tra.2019.09.002
Received 10 October 2018; Received in revised form 28 June 2019; Accepted 5 September 2019
Available online 11 September 2019
0965-8564/

Næss, 2001; OECD, 2018). On the other hand, travel satisfaction is relevant to subjective well-being (SWB) (Friman et al., 2017; Stutzer and Frey, 2008), which is an important component of social sustainability. Previous research suggests that neighborhood satisfaction, personal relationships satisfaction, and perceived physical health are higher in compact urban areas, while anxiety is lower in sprawled suburbs, and overall levels of SWB are similar for the two types of urban form (Feng et al., 2017; Lederbogen et al., 2011; Mouratidis, 2017, 2018a, 2019). To obtain a more complete picture of the role of the built environment in SWB (see Mouratidis, 2018b), we also need to understand in what ways travel satisfaction is shaped by the physical built environment and whether travel satisfaction is higher in compact or sprawled urban forms. Such knowledge would offer not only important theoretical advancements but also empirically-based input for policymakers.

This article aims to assess if and how urban form affects travel satisfaction. The article answers two main research questions. (1) Which residents have higher levels of travel satisfaction (for commute as well as leisure), those living in compact areas or those living in sprawled ones? (2) In what ways does urban form affect commute satisfaction? To address these questions, the study analyzes survey data from 45 neighborhoods in Oslo metropolitan area and qualitative data from in-depth interviews with local residents. Oslo is a suitable case for this research as it includes a high variety of urban forms and transport modes. A mixed-methods approach is employed, comprising statistical analysis as well as qualitative data analysis.

The scientific contribution of the article is threefold. (a) It provides new insights into whether it is denser or less dense urban forms that facilitate higher travel satisfaction. Little evidence exists on this topic. (b) It reveals the pathways through which urban form influences travel satisfaction by assessing the mediating effects of travel behavior. (c) It uses a mixed-methods approach, which is rarely found in travel satisfaction studies, providing a more nuanced understanding of causal pathways. The article has societal contributions that revolve around discourses on urban sustainability as well as mobility and quality of life in cities. The analysis of the impact of denser versus less dense urban forms on travel satisfaction reveals possible synergies or conflicts between environmental and social sustainability. Moreover, by examining urban form, travel behavior, and travel satisfaction altogether, the article can discuss implications of the direct influence of travel behavior on travel satisfaction as well as the indirect influence of urban form on travel satisfaction via travel behavior. Such knowledge has policy implications on how urban and transport planning can influence travel experience, thus contributing to quality of life in cities.

2. Literature review

2.1. Urban form and travel behavior

Much research on relationships between the built environment and travel has focused on local-scale characteristics. However, the attribute of the dwelling that has shown the strongest impact on travel behavior is its location within the overall urban structure (Ewing and Cervero, 2010; Næss, 2012; Næss et al., 2019; Stevens, 2017). The destinations of most daily-life trips in modern cities are outside the residential neighborhood. Overall travel distances are therefore likely to be influenced more by how far the dwelling is located from the main clusters of potential trip ends than by attributes internal to the residential area. Such clusters normally reflect the city's center structure, with the largest cluster of facilities within and next to the main downtown area. Local built environment characteristics also influence travel behavior, but not to the same extent. Neighborhood density influences the population base for transit and thereby average walking distances to stops and the frequency of departures. Parking conditions and the availability of local grocery stores normally also vary with the density of the local area. However, in most metropolitan areas, neighborhood densities are influenced by how far from the city center the neighborhood is located (but of course also by policies to plan facilities in neighborhoods, arrange accessibility by specific modes, etc.). This is clearly the case in the urban region investigated in this article, Oslo metropolitan area, where neighborhood densities show a clear gradient from high inner city densities to low densities in the outer suburbs.

In line with this, a large number of studies, mainly in Europe, but also in America, Australia and Asia, have found that residents of suburban neighborhoods far away from the city center travel longer overall distances, longer distances by car and make a higher proportion of their travel by car, compared with their inner-city counterparts (for overviews, see Ewing and Cervero, 2010; Næss, 2012; Stevens, 2017). By combining qualitative and quantitative research methods and including longitudinal analyses in addition to the traditional cross-sectional approach, recent studies have uncovered key motivations, rationales and constraints underlying observed associations between built environment characteristics and travel, demonstrating that these relationships represent causality and not merely correlations. Oslo is one of the metropolitan areas that has been investigated through this mixed-methods approach (Næss et al., 2018, 2019). In monocentric cities such as Oslo, residential distance to the city center has been found to exert particularly strong influences on commuting distance and distance traveled by car for commuting (Næss et al., 2019).

The influences of residential proximity to lower-order centers (at district or neighborhood level) have generally been found to be much weaker than those of proximity to the main city center. Local-area population density has also been found to be rather weakly related to car driving distances when controlling for the location of the neighborhood in question relative to the city center (Ewing and Cervero, 2010; Lee et al., 2011, Næss et al., 2019) but more strongly related to the proportion of the overall distance traveled by car and particularly the walk/bike proportion of the distance traveled (Næss et al., 2019).

The above-mentioned effects of residential location on travel persist also when including residential preference variables to control for attitude-based residential self-selection. The magnitude of the estimated effects have in some studies then diminished somewhat, but the effects of residential location variables on travel are still considerable – which should come as no surprise since the underlying causal mechanisms by which residential location influences travel exist independent of any attitude-based residential self-selection. In our case metropolitan area Oslo, people choose their residential location mainly based on concerns other than travel

attitudes, which influence residential location choices only at second tier (Wolday et al., 2018).

Reflecting an environmental agenda concerned about the energy use and emissions from urban travel, most of the above-mentioned studies have focused on travel distance rather than travel time. Since inner-city dwellers tend to make a larger proportion of their trips by non-motorized modes and because car driving is normally faster on suburban roads than closer to the city center, the differences between suburbanites and residents of central districts are usually smaller in travel time than in traveling distances. In some studies, the travel time of centrally residing commuters has even been found to be on average longer than among those living peripherally (Fouchier, 1998; Schwanen et al., 2004). A study in Copenhagen metropolitan area still found that suburbanites tend to spend somewhat more time on traveling than inner-city dwellers do (Næss, 2006). Unpublished data from the above-mentioned study in Oslo metropolitan area show similar results, with stronger effect of residential distance to the city center than in the Copenhagen study. On the other hand, the time spent on non-motorized travel for commuting as well as non-work purposes tends to increase, the closer to the city center of Oslo the dwelling is located (Stefansdottir et al., 2019).

2.2. Travel satisfaction

Over the past decade, the impact of urban policies on residents' well-being has gained increasing interest. Well-being is usually interpreted as an individual's assessment of her life circumstances in relation to individual needs, and therefore termed subjective well-being (SWB). While alternative conceptualizations and definitions of well-being exist (Ryan and Deci, 2001), a common approach is to regard SWB as consisting of cognitive components, indicating how satisfying one's life is overall, and affective components, referring to the experience of positive and negative emotions (Diener and Suh, 1997). It has been argued (Ettema et al., 2010) that travel relates to SWB in two distinct ways. First, travel allows people to participate in activities and thereby achieve their goals, which increases SWB. Various studies indicate that a higher satisfaction with activities leads to a higher overall well-being. In addition, studies in social exclusion provide evidence that a lack of access to travel options and activities is associated with lower levels of well-being (Delbosc and Currie, 2011). Second, the daily experience of travel may have an impact on overall well-being (Friman et al., 2017). For instance, a lower satisfaction with the daily commute may have a significant impact on overall life satisfaction (see also De Vos et al., 2013; Stutzer and Frey, 2008).

The impact of the travel experience on overall well-being has led to studies of travel satisfaction, measuring the degree of satisfaction with daily travel. Studies of travel satisfaction have applied a variety of measurement methods and conceptualizations, ranging from unidimensional (Susilo and Cats, 2014; Mao et al., 2016) to multidimensional scales. An example of the latter is the satisfaction with travel scale (STS: see Friman et al., 2013), which includes both cognitive and affective items. It should be noted, though, that irrespective of measurement scale, studies of travel satisfaction lead to some consistent outcomes with respect to the factors that influence travel satisfaction. Another aspect on which studies of travel satisfaction differ is the timescale that is assumed. Travel satisfaction can be measured at a momentary level, referring to the experience of a specific instance of a trip (e.g. Susilo and Cats, 2014), or refer to a particular type of trip in general (e.g. Olsson et al., 2013).

Existing studies have elicited various factors that influence travel satisfaction (for an overview see Ettema et al., 2016). The main factor influencing travel satisfaction appears to be travel mode. Across geographical settings, using active travel modes results in the highest levels of travel satisfaction, whereas public transport is associated with lower travel satisfaction (De Vos et al., 2016; Ye and Titheridge, 2017). This finding suggests that active travel has some inherent qualities that makes it more pleasant. These are likely related to the physical activity involved. Prestige, autonomy and a feeling of mastery may contribute to the relatively high satisfaction with car travel.

Apart from travel mode, travel duration has been found as a key influence of travel satisfaction, with longer durations being associated with lower travel satisfaction (Morris and Guerra, 2015). It has also been suggested that while the majority of commuters want to reduce their travel time, they would not be willing to eliminate it (Redmond and Mokhtarian, 2001). For car commuting, it has been found that congestion and perceived lack of safety negatively impact commute satisfaction (Ettema et al., 2013). For public transport, Ettema et al. (2016) report that travelling in the peak (Mao et al., 2016), use of ICTs and engaging in relaxation and entertainment activities (Ettema et al., 2012) have a negative effect on travel satisfaction. The latter is taken as an indication of boredom during commuting. Having company, however, adds positively to the satisfaction with the public transport commute. With respect to commuting by active travel modes, weather is found to influence commute satisfaction, with satisfaction being lower in the winter season (St-Louis et al., 2014).

2.3. Urban form and travel satisfaction

Although the field of urban form and travel behavior (see Section 2.1) is widely investigated and research in the field of travel satisfaction (see Section 2.2) has been active, little research has explored the interrelationships between urban form, travel behavior, and travel satisfaction. One study from Xi'an, China suggests that the built environment indirectly influences commute satisfaction through affecting travel mode choice and congestion (Ye and Titheridge, 2017). Other findings suggest that the higher the accessibility to facilities, public transport, and green space, the higher the travel satisfaction (Dong et al., 2016; Feng et al., 2017). One study on leisure travel satisfaction from the city of Ghent in Belgium finds that suburban dwellers are significantly more satisfied with their travel for leisure than urban dwellers, despite longer trips in time and distance (De Vos and Witlox, 2016). Despite these insights, there is still a lack of knowledge on the pathways through which urban form influences travel satisfaction and what this implies for travel satisfaction in different urban settings.

3. Data and methods

3.1. Data sources

To investigate how urban form affects travel satisfaction, this study utilizes data from the metropolitan area of Oslo. Oslo is the capital city of Norway. Based on 2018 statistics, the population of the metropolitan area of Oslo was approximately 1,300,000–1,500,000 (depending on the definition), of which slightly above one million living within the continuous urban area of Oslo (the morphological city). A high diversity in urban form attributes and transportation modes is concentrated in Oslo, making it a suitable case for such research. The high diversity in urban form attributes and transportation modes captured by the present study enables comparisons between various urban form attributes (ranging from sprawled suburbs to high-density inner-city areas) and travel behaviors, and reduces problems pertaining to omitted variables that could lead to biased estimates. This expands the relevance of the findings to other geographical contexts. The study employs both quantitative and qualitative data collected between May and June 2016 for the research project "Compact City or Sprawl? The Role of Urban Form in Subjective Well-Being".

Quantitative data come from a survey (N = 1344) with residents of 45 neighborhoods in the metropolitan area of Oslo. These neighborhoods cover various inner-city as well as suburban areas, as seen in Fig. 1. The survey sample is characterized by a high representativeness in sociodemographic characteristics and a large variety in urban form attributes (see Appendix A for details). In addition, since multivariate regression analysis in the study controls for sociodemographic variables, deviations from the population do not materially influence the outcomes. A random sample selection was employed for the neighborhoods covered in the survey. The addresses of all residents living within the postal zones of these neighborhoods were collected from municipal registers. For each postal zone, a random selection of addresses was performed. Additional selection criteria were that only adult residents and only one member from each household could be selected. An invitation letter was sent to the selected residents including a link to an electronic survey.

Qualitative data come from 10 qualitative, in-depth, semi-structured interviews with selected residents. The duration of the interviews varied from approximately one hour to one and a half hour. The aim of the interviews was to provide more insights into the context and possible explanations on causal mechanisms. The interviewees were selected using the results of the survey. The survey included a question asking whether the participant would be available for an interview. Based on these answers, 10 interviews

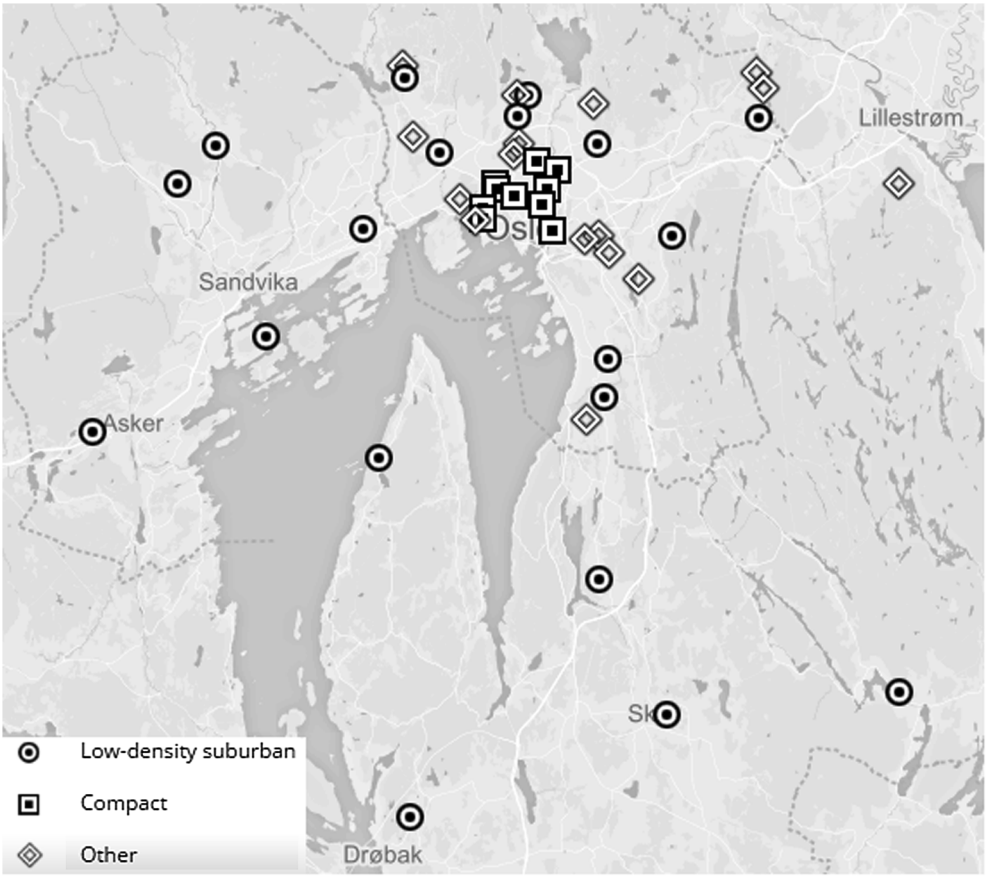

Fig. 1. Selected neighborhoods within the metropolitan area of Oslo.

were conducted, 5 with residents of compact inner-city areas and 5 with residents of sprawled suburbs.

3.2. Variable descriptions

Table 1 presents descriptive statistics for all variables used in the study. Satisfaction with travel to main occupation (i.e. commute satisfaction) was measured by asking residents "What are your general feelings about your travel to your main occupation?" Satisfaction with travel for other purposes was measured by asking residents "What are your general feelings about your travel for purposes other than work/education?" Participants were asked to consider the time spent and mode(s) of travel. A scale from "very negative" (1) to "very positive" (5) was used for both measures. To measure trip duration to main occupation, participants were asked how much time they typically spent to arrive at their main occupation (door to door) in minutes. Participants were also asked to identify the main travel mode they typically used to travel to their main occupation. The majority of the participants who worked or were students used one of the following modes to travel to their main occupation: walk, bike, bus/tram/metro, train, and car. These represent altogether 97% of the travel modes used for commuting among the study's sample and, therefore, the analysis for commute satisfaction focuses on these travel modes.

To examine the role of urban form in travel satisfaction from various angles, quantitative analysis in this study uses two different sets of variables. The first is a dichotomous variable "compact" which is based on a qualitative categorization of neighborhoods into compact and sprawled. Analysis using this variable includes sample only from these two types of urban form. Neighborhoods are classified as compact when all following conditions are met: neighborhood population density is high, the main building type is the apartment block, and commercial and residential land uses are mixed. On the other hand, the conditions for characterizing a neighborhood as sprawled are: neighborhood population density is low, the main building type is the single-family detached house, and commercial and residential land uses are mostly separate. For compact neighborhoods the mean population density is 211 persons per hectare, while for sprawled neighborhoods it is 29 persons per hectare. Neighborhoods that do not belong to any of these two urban form categories are mostly neighborhoods of medium density and mixed types of housing. A list of the study's neighborhoods and their urban form attributes can be found in the Appendix A.

The second set of variables employed to examine how urban form influences travel satisfaction focuses on specific urban form attributes and relies on sample from all types of neighborhoods and urban forms. Thereby, the statistical effects that are not captured by the first set of variables are captured by the second set of variables. The characteristics of the urban form are assessed with two continuous variables: neighborhood density and distance to city center. In addition to capturing a wider range of urban forms, this approach is more sophisticated since it assesses both local urban form density as well as the location of the neighborhood within the city. To measure neighborhood density, the population of each neighborhood is divided by the coverage of the area in hectares. To measure distance to city center, the distance between the centroid of each neighborhood and the city center is calculated along the

Table 1
Descriptive statistics of all variables.

Variables	N	Min/Max	All (N = 1344)		Compact (N = 535)		Sprawl (N = 504)		*t*-Test
			Mean	s.d.	Mean	s.d.	Mean	s.d.	
Satisfaction with travel to main occupation	935	1/5	3.79	(0.90)	3.91	(0.86)	3.61	(0.96)	*
Satisfaction with travel for other purposes	1294	1/5	3.80	(0.74)	3.90	(0.69)	3.64	(0.77)	*
Commuting characteristics									
Trip duration to main occupation (minutes)	935	2/150	27.71	(16.18)	23.90	(12.07)	33.09	(20.38)	*
Walk	937	0/1	0.19	(0.39)	0.32	(0.47)	0.07	(0.25)	*
Bike	937	0/1	0.14	(0.35)	0.17	(0.38)	0.10	(0.30)	*
Bus, tram, metro	937	0/1	0.34	(0.48)	0.39	(0.49)	0.23	(0.42)	*
Train	937	0/1	0.07	(0.25)	0.03	(0.17)	0.12	(0.32)	*
Car	937	0/1	0.26	(0.44)	0.09	(0.29)	0.49	(0.50)	*
Urban form measures									
Compact (sprawl = 0, compact = 1)	1039	0/1	0.51	(0.50)	1.00	(0.00)	0.00	(0.00)	*
Neighborhood density (persons/ha)	1341	14/306	112.93	(88.04)	211.23	(44.12)	28.73	(9.11)	*
Distance to city center (km)	1344	0.70/46.20	10.22	(10.84)	2.39	(0.87)	20.47	(11.04)	*
Sociodemographic variables									
Age	1344	19/94	50.16	(15.71)	43.06	(14.40)	55.78	(14.18)	*
Unemployed	1339	0/1	0.03	(0.16)	0.03	(0.17)	0.02	(0.14)	
Living with partner/spouse	1329	0/1	0.61	(0.49)	0.49	(0.50)	0.74	(0.44)	*
Adjusted household income (1000 s NOK)[a,b]	1259	35/4330	642.2	(321.08)	625.02	(288.68)	669.09	(361.27)	*
Female	1331	0/1	0.53	(0.50)	0.52	(0.50)	0.54	(0.50)	
Non-Norwegian	1342	0/1	0.09	(0.28)	0.11	(0.31)	0.08	(0.27)	
Household with children	1334	0/1	0.32	(0.47)	0.2	(0.40)	0.43	(0.50)	*
Respondent has college degree or higher	1341	0/1	0.79	(0.41)	0.84	(0.37)	0.74	(0.44)	*

* A *t*-test of difference in mean shows significant differences between compact and sprawl at $p < 0.05$.
[a] Yearly household income divided by the square root of household size.
[b] Median adjusted household income is 635,000 NOK for compact and 636,000 NOK for sprawl residents.

pedestrian network in kilometers. It should be noted that neighborhood densities are influenced by the distance to the city center. Both for economic (Alonso, 1960) and cultural (Fishman, 1996) reasons, neighborhood densities tend to be higher in central than in peripheral parts of an urban area – a tendency highly apparent also in the Oslo metropolitan area (Næss et al., 2019).

4. Results

4.1. Quantitative analysis

4.1.1. Urban form and travel satisfaction

Table 2 presents models examining the impact of urban form on travel satisfaction. Results suggest that both satisfaction with travel to main occupation and satisfaction with travel for other purposes are significantly higher among compact-city residents than among residents of sprawled suburbs (Models A1 and B1). Models A2 and B2, which examine all types of urban form, indicate that the higher the neighborhood density the higher the travel satisfaction. Distance to city center plays a significant role only in the case of travel for other purposes, where travel satisfaction is significantly higher the closer one lives to the city center. For commute satisfaction, it is neighborhood density that exhibits a significant positive effect, while the effect of shorter distances to city center is not significant.

Table 2
Regression models examining the impact of urban form on travel satisfaction.

Variables	Satisfaction with travel to main occupation		Satisfaction with travel for other purposes	
	A1	A2	B1	B2
Urban form measures				
Compact	0.205***		0.220***	
Neighborhood density		0.140**		0.097*
Distance to city center		−0.069		−0.133***
Sociodemographic variables				
Age	0.102*	0.083*	0.099**	0.120***
Unemployed			−0.086**	−0.065*
Living with partner/spouse	−0.109**	−0.082*	−0.045	−0.022
Adjusted household income	0.037	0.024	0.069*	0.044
Female	0.064[a]	0.056[a]	−0.030	−0.017
Non-Norwegian	0.022	−0.001	0.030	0.025
Household with children	0.091*	0.089*	0.043	0.040
College degree or higher	0.015	0.027	−0.028	−0.009
Summary statistics				
N	680	866	911	1181
R-squared	0.050	0.042	0.053	0.046

Notes: All coefficients shown are standardized.
[a] $p < 0.10$.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

4.1.2. Urban form, trip duration, and travel modes

Table 1 suggests that commuting characteristics vary significantly between compact inner-city areas and sprawled suburbs. Trip duration to main occupation is significantly higher on average for residents of sprawled areas compared with residents of compact areas (33.81 versus 23.78 min). This is also supported by regression results in Model 1 of Table 3. Model 2 of Table 3 suggests that both local neighborhood density and distance to the city center play significant roles in trip duration. Higher neighborhood densities are associated with lower trip durations and shorter distances to city center are also associated with lower trip durations. Although both statistical effects are significant, the effect of distance to city center is stronger.

Another substantial difference in commuting characteristics between urban form types concerns modal split. As seen in Table 1 and Fig. 2, compact-city residents walk to their main occupation to a much higher extent than suburbanites do. More compact-city residents use their bikes to travel to their main occupation compared with suburbanites, although the difference is not as large as it is for walking. The usage of public transport modes such as bus, tram, and metro is also significantly higher on average in the compact inner city. The train is, on the other hand, more commonly used by suburbanites as they tend to use it to commute to central locations of the city. The difference in car usage between the compact inner city and the sprawled suburbs is very large. About half of the suburbanites in the sample use a car to travel to work or studies, while less than one tenth of compact inner-city residents use a car for this purpose.

Table 3
Regression models examining the impact of urban form on trip duration to main occupation.

Variables	Trip duration to main occupation	
	1	2
Urban form measures		
Compact	−0.305***	
Neighborhood density		−0.144**
Distance to city center		0.182***
Sociodemographic variables		
Age	−0.068	−0.040
Living with partner/spouse	0.068	0.053
Adjusted household income	0.019	0.008
Female	−0.041	−0.034
Non-Norwegian	0.005	−0.009
Household with children	−0.052	−0.073*
College degree or higher	−0.008	0.011
Summary statistics		
N	679	866
R-squared	0.088	0.082

Notes: All coefficients shown are standardized.
[a]$p < 0.10$.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

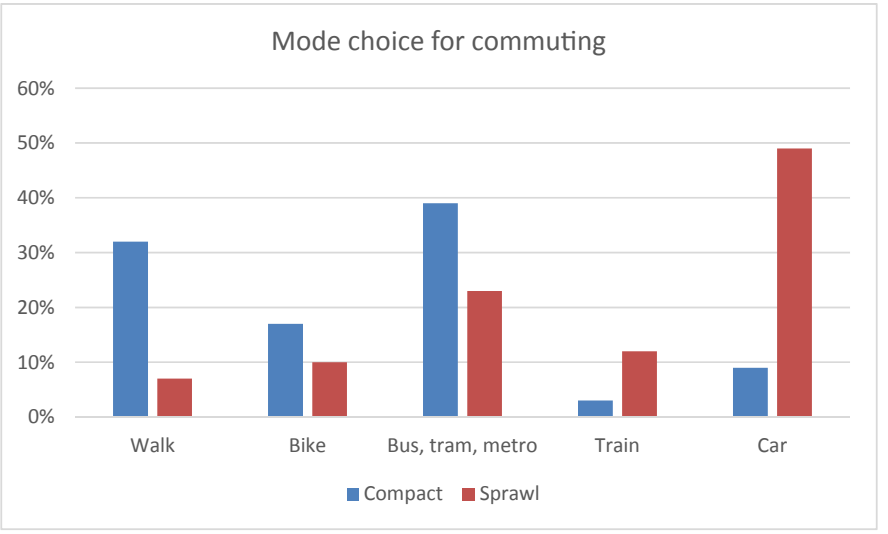

Fig. 2. Commuting mode choice for residents of compact and sprawled neighborhoods.

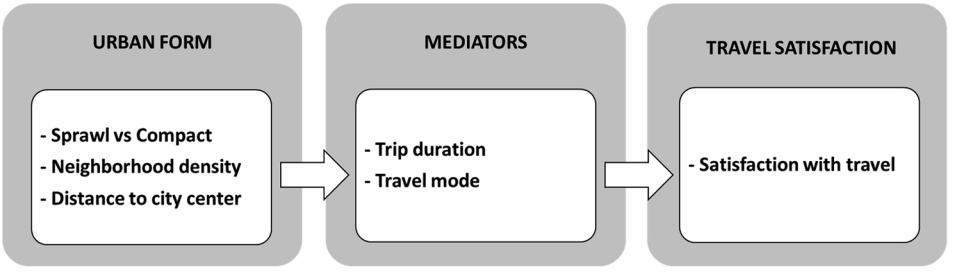

Fig. 3. Conceptual model explaining how urban form affects travel satisfaction.

Table 4
Regression models examining how urban form affects commute satisfaction.

Variables	Satisfaction with travel to main occupation					
	1	2	3	4	5	6
Urban form measures						
Neighborhood density	0.140**	0.076[a]	−0.035	−0.035	−0.035	−0.035
Distance to city center	−0.069	0.005	0.043	0.043	0.043	0.043
Commuting characteristics						
Trip duration		−0.416***	−0.419***	−0.419***	−0.419***	−0.419***
Walk			0.392***	0.136*	0.164***	Reference
Bike			0.206***	−0.025	Reference	−0.148***
Bus, tram, metro			0.190***	−0.121*	−0.088[a]	−0.288***
Train			0.167***	Reference	0.018	−0.089*
Car			Reference	−0.286***	−0.256***	−0.439***
Sociodemographic variables						
Age	0.083*	0.069*	0.052	0.052	0.052	0.052
Living with partner/spouse	−0.082*	−0.062[a]	−0.067*	−0.067*	−0.067*	−0.067*
Adjusted household income	0.024	0.018	0.037	0.037	0.037	0.037
Female	0.056[a]	0.044	0.042	0.042	0.042	0.042
Non-Norwegian	−0.001	−0.005	−0.027	−0.027	−0.027	−0.027
Household with children	0.089*	0.058[a]	0.056[a]	0.056[a]	0.056[a]	0.056[a]
College degree or higher	0.027	0.029	−0.003	−0.003	−0.003	−0.003
Summary statistics						
N	866	864	864	864	864	864
Adjusted R-squared	0.032	0.191	0.285	0.285	0.285	0.285

Notes: All coefficients shown are standardized.
[a] $p < 0.10$,
* $p < 0.05$,
** $p < 0.01$,
*** $p < 0.001$.

4.1.3. How urban form affects travel satisfaction

This study examines whether and to what extent these differences in trip duration and modal split for commuting are responsible for the higher commute satisfaction found in compact neighborhoods compared with sprawled ones. Therefore, trip duration and travel mode are assessed as mediators between urban form and travel satisfaction as shown in the conceptual model in Fig. 3.

Table 4 presents the results of the analysis that examines how urban form affects satisfaction with travel to main occupation based on the conceptual model in Fig. 3. Model 1 includes only urban form variables and socio-demographics, similarly to Model A2 in Table 2, showing that higher neighborhood densities are significantly associated with higher travel satisfaction. Model 2 additionally includes trip duration, which is found to be significantly associated with travel satisfaction. This statistical effect considerably reduces the positive effects of higher neighborhood densities and short distances to city center on travel satisfaction. This indicates that urban form indirectly influences travel satisfaction through its influence on trip duration (as per Table 3). Models 3–6 additionally include dummy variables of different travel modes. As Models 3–6 suggest, travel modes also have a significant impact on travel satisfaction. With the addition of both trip duration and travel modes in Models 3–6, the statistical effects of urban form become nonsignificant. This suggests that urban form influences travel satisfaction mainly through affecting trip duration and travel modes. Differences in trip duration and travel modes seem to be the main reason why commute satisfaction is higher in compact areas.

The analysis in Models 3–6 has been conducted with different travel modes as a reference in order to identify possible significant differences between them. Model 3 uses car as a reference and shows that all other travel modes have significantly higher positive effects on travel satisfaction. The car is found to be the mode with the least positive association with travel satisfaction. Model 4 uses train as a reference and shows that there is no significant difference between train and bike, while walking is significantly more pleasant, and bus, tram, and metro as well as car are all significantly less pleasant. Model 5 uses bike as a reference and shows that walking is significantly more pleasant, while bus, tram, and metro as well as car are all significantly less pleasant. Bike and train are found to be equally pleasant in Model 5 as also found in Model 4. Model 6 uses walking as reference and shows that all the other travel modes are significantly less pleasant. After using different travel modes as a reference, and controlling for trip duration, the travel modes to main occupation are evaluated from most to least pleasant as follows: (1) walk, (2) bike and train, (3) bus, tram and metro, and (4) car. All these differences are significant. The most emphatic results concern walking and car driving. Walking is found to be by far the most pleasant travel mode and car driving is by far the least pleasant.

The conceptual model of Fig. 3 has been successfully tested, as results in Table 4 suggest. The different types of mediators all exhibit significant associations with travel satisfaction, and when they are all included in the model, the effects of urban form become nonsignificant. This means that these mediators explain most of the indirect influence of urban form on satisfaction with travel to main occupation. The adjusted R-squared also gradually increases as each mediator is included in the model. To understand which of the mediators has the largest impact on travel satisfaction, the analysis in Table 4 has been conducted by including the mediators in

different order. When including travel modes instead of trip duration in Model 2, the adjusted R-squared change from Model 1 to Model 2 is smaller than the one shown in Table 4. This indicates that trip duration has a stronger impact on travel satisfaction than travel modes.

Another check that was performed is Redmond and Mokhtarian's (2001) hypothesis that US commuters do not really want to minimize their travel time, but rather optimize it, where the optimal time was suggested to be around 15 min. To test this, the trip duration variable was transformed into a variable measuring the absolute value of the difference between the actual trip duration and 15 min. Results showed, nevertheless, that actual trip duration exhibits greater statistical effects on travel satisfaction than the trip duration difference from 15 min. This finding implies that, on average, Oslo residents do want to minimize their travel time. This difference between commuters in Oslo and US cities can be perhaps attributed to differences in urban form characteristics, transport infrastructure, and mobility culture.

Fig. 4 presents mediation analysis examining relationships between urban form, travel behavior, and travel satisfaction. Structural equation modeling (SEM) software AMOS (version 25) was used. Bootstrapping was performed to estimate significance levels. Indirect effects of urban form on travel satisfaction are significant, confirming that trip duration and travel mode mediate this relationship. Total effects of both neighborhood density and proximity to city center on travel satisfaction are positive and significant. The direct effects of urban form characteristics – density and distance to city center – on travel satisfaction are nonsignificant. This suggests that trip duration and travel mode fully explain the influence of urban form on travel satisfaction.

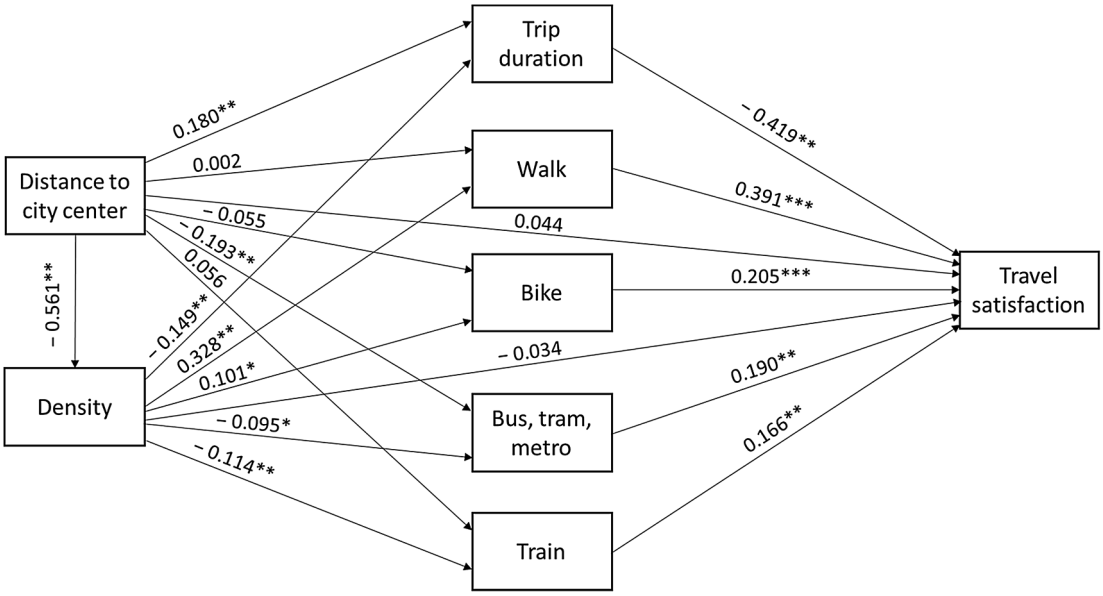

Fig. 4. Path diagram with structural equation modeling. *Notes*: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. Direct effects shown are standardized. Significance levels for standardized direct effects are bootstrap approximations. Number of observations = 864. Bootstrap replications = 1000. Goodness-of-fit measures: $X^2 = 216.899$, df = 30, $p = 0.000$; Root Mean Squared Error of Approximation (RMSEA) = 0.085; Comparative Fit Index (CFI) = 0.920. The reference travel mode is the Car. The model includes controls for sociodemographic attributes, which are not shown for simplicity. Indirect effects (standardized): Distance to city center → Travel satisfaction: −0.192 (bootstrap $p = 0.002$); Density → Travel satisfaction: 0.175 (bootstrap $p = 0.003$). Total effects (standardized): Distance to city center → Travel satisfaction: −0.148 (bootstrap $p = 0.002$); Density → Travel satisfaction: 0.140 (bootstrap $p = 0.005$).

4.2. Qualitative analysis

The analytical approach of the study also includes empirical knowledge from qualitative interviews. The purpose of the interviews is explanatory within a mixed-methods research design (see e.g. Næss, 2018). The interviews offer qualitative information on the context of the metropolitan area, its urban form characteristics and travel modes, supporting interpretation of quantitative results in terms of causal mechanisms underlying the examined relationships.

The qualitative interviews show several examples of how travel modes, trip duration, trip distance and urban form characteristics affect the interviewees' satisfaction with their travel. Travel modes and trip duration appear to influence their travel satisfaction directly, while trip length influences travel satisfaction indirectly through its bearing on trip duration and the perceived relevance of non-motorized travel modes. Urban form characteristics influence travel satisfaction mainly indirectly by influencing trip distances and the facilitation of different travel modes, but partly also directly through the pleasantness of the route surroundings of the trips. Below, some examples will be given of the various ways in which different urban form characteristics (compact inner-city versus low-density suburban) affect travel satisfaction indirectly and directly.

4.2.1. Travel modes

Walking is the travel mode that most of the interviewees say they prefer. Seven of the ten interviewees talk about walking in very positive words. The inner-city resident ID1 describes walking as the ideal mode and walks to destinations not too far away (gym and the doctor) but switches between walking and using tram to her workplace, which is quite far from home. The retired suburbanite ID2 prefers walking when going for grocery shopping and visiting friends and found it nice to walk to her nearby workplace before retirement. She also talks positively about walking ten minutes to the tram stop. Suburbanites ID4 and ID5 both prefer walking due to the exercise it involves. For ID4, the walking referred to is a ten-minute downhill stroll to the grocery store in the a local center, which he prefers instead of taking the bus. Inner-city resident ID6 characterizes walking as her favorite travel mode, among others because she can listen to podcast when moving along. Another positive aspect of walking the opportunity it gives for meeting people on the way, emphasized by inner-city dweller ID7. In more general terms, ID8 (also a resident of the inner city) says that his feelings when walking in the neighborhood are very positive unless it is too crowded.

On the negative side, ID6 and ID8 do not feel positively about walking when streets are crowded, such as in the downtown area on Saturdays (ID6).

The interviewees have more mixed perceptions of how satisfactory biking is. Only one interviewee (ID6), explicitly mentions biking as a nice way of traveling. This inner-city resident considers biking as the second best travel mode (after walking). On the other hand, ID9, who lives in a suburb where sidewalks are often missing along the roads, finds biking rather unsafe and exposed to reckless car drivers. Another suburbanite (ID5) thinks that biking is not for elderly people. The inner-city dweller ID7 is frustrated by the poor and non-continuous bike paths in Oslo.

Opinions are also divided regarding how satisfactory it is to travel by public transport, where inner-city residents are more positive than interviewees living in the suburbs. Referring to public transport in general without specifying any particular mode, ID6 emphasizes that it is faster than walking and that it can bring her home after having a glass of wine, while ID7 finds public transport a good mode in the winter when walking is not so pleasant. Both these interviewees live in the inner city. ID10, also an inner-city resident, considers tram as the most pleasant way of traveling due to its smooth movement on rails and nice view from the carriage. Another inner-city resident, ID1, also considers tram as the most enjoyable public transport mode, ranked second after walking. The suburbanite ID4 does not talk much about public transport but mentions night buses as a positive service enabling him to get home after visits to bars etc. None of the interviewees express any opinions about how satisfactory or unsatisfactory it is to travel by metro, although some mention that this is a mode they can use when relevant.

The suburban interviewee ID9 speaks negatively about public transport in general and particularly bus transportation. She finds travel by public transport complicated when there is a need to make many transfers, which is the case for her commuting trips. She is particularly frustrated with the low reliability of the bus service making up part of her commute, which is often delayed and does not reach the connecting train, sometimes does not show up at all, and sometimes departs too early. In addition, shelters are currently missing at her stop. One inner-city interviewee (ID10) is also dissatisfied with bus traveling, which she finds 'awful' due to unsmooth movement and drivers who drive 'like maniacs'. Two interviewees – one inner-city dweller (ID7) and one suburbanite (ID5) – talk about missing park and ride facilities as a negative aspect of traveling by public transport. For ID7, this is not based on her own experience but more a concern she thinks policy-makers should address to make more car drivers shift to public transport. ID5 also mentions high fares as an unsatisfactory feature of train travel.

One-half of the interviewees associate car travel with unsatisfactory features while only three interviewees (all suburban residents) mention positive aspects of this mode. Two of the latter interviewees point to the easier access the car offers to shopping opportunities (ID3) and city facilities (ID4). ID9 talks positively about being a car passenger with her boyfriend to the train station instead of having to rely on the unpredictable bus line for this part of her commute. On the other hand, three other suburbanite interviewees speak negatively about car travel. ID2 and ID5 point at the congestion and chaos caused by car traffic in the city center, and ID4 mentions that you cannot drive if you want a drink. Inner-city resident ID6 makes the same point and also mentions parking difficulties in her neighborhood. She thinks car driving creates habits making you lazy, besides being not good for the environment. Finally, ID10 (also an inner-city dweller) states that she and her partner are generally not fond of having a car and try to avoid it. If they move, they would therefore prefer a place where they do not need to have a car.

4.2.2. Travel time and distance

Only three interviewees explicitly mention the duration of the journey as an aspect influencing their travel satisfaction. ID1 speaks positively about her short travel time, while ID6 says that she would not like to live at a place where she needed to spend a lot of time on traveling to reach her activities, since this would steal time that could better be spent with her child and husband. ID9 does not stated explicitly that she perceives her 1.5-h long one-way commuting time as negative, but in some way this shines through. The fact that the remaining seven interviewees do not talk explicitly about the time spent on traveling hardly means that time consumption is unimportant to them. Rather, the desirability of saving time seems to be taken for granted; as something that goes without saying. Similarly, only three interviewees mention trip distance, all emphasizing short distance as a positive quality. ID6 is happy that all her regular destinations are within 3 km so she can walk. Similarly, ID10 emphasizes that both she and the spouse can reach their jobs with a few minutes' walk. ID8 simply says that short distances to everything is the most important thing. All these three interviewees live in the inner city. Short distance is valued partly because it reduces the travel time with a given mode, and partly because it enables interviewees to use their preferred travel mode (walking).

4.2.3. Residential location and neighborhood qualities

Five interviewees talk explicitly about characteristics of their residential environment as something affecting their travel

satisfaction. ID6 thinks living in proximity to facilities and public transport is important and appreciates that her present inner-city residential location enables her to 'walk to everything'. When they move (in two years), they will move to a dwelling close to the metro. The retired interviewee ID8 states that even though they do not any longer go to work and therefore could live any place now, they still find it good to have short distance to the city center. ID7 appreciates the charming paths and streets for walking in her village-like inner-city neighborhood. On the other hand, interviewees speak negatively about residential locations far away from relevant facilities. ID6 would like to avoid living at a place that requires long daily-life trips (and does not want to spend her time on mending the garden and cleaning a big house). Suburbanite ID9 thinks the distance to the nearest center is too long for biking. She thinks living in an area where you can access things on foot is desirable, but high housing costs make such neighborhoods unaffordable to her.

The interviewees' statements about urban form characteristics and different aspects of their daily-life travel illustrate several mechanisms underlying the patterns found in the statistical material. Suburbanites often live further away from relevant trip destinations than inner-city residents do, and they therefore tend to spend more time on traveling, which reduces their satisfaction with their daily-life travel. The longer trip distances also reduce the possibility of reaching the destinations on foot and thus hamper the use of the travel mode mentioned by the majority of interviewees and respondents as the most satisfactory. Suburbanites depend more on car travel, and if the trip destinations are in the areas closer to the city center (which is often the case when commuting) parts of the journeys will be characterized by congested driving conditions, which are perceived as less satisfactory. Moreover, suburbanites who travel by public transport often perceive these modes as inflexible, complicated (due to need for transfers) and time-consuming. In contrast, inner-city dwellers usually perceive the public transport service near their residence as excellent. On the other hand, congested streets may reduce inner-city residents' travel satisfaction when walking, biking or going by bus or tram in their local districts.

5. Discussion

5.1. Discussion of the results

The results of this study suggest that urban form can significantly influence travel satisfaction. Compact urban forms are found to promote higher travel satisfaction. This has been found for both satisfaction with the commute to work or studies as well as for satisfaction with travel for leisure. Both are significantly higher for residents of compact neighborhoods. Results for all types of urban form suggest that local neighborhood density is significantly associated with both commute and leisure travel satisfaction. According to both quantitative and qualitative analysis in the study, this is because higher local densities promote shorter trip durations, enable walking to nearby facilities, facilitate public transport, while they discourage car travel which is found to be the least pleasant travel mode in Oslo. Neighborhood proximity to the city center is also found to promote higher commute satisfaction and leisure travel satisfaction. According to the analysis of the study (Fig. 4), neighborhood proximity to city center poses an indirect positive effect on commute satisfaction by influencing neighborhood density as well as by reducing trip duration.

The finding that leisure travel satisfaction is higher in compact urban areas contrasts with the results of the study by De Vos and Witlox (2016) who investigate satisfaction with travel for leisure in Ghent, Belgium. They find that leisure travel satisfaction is significantly higher for low-density suburban residents. This interesting difference in results can be attributed to several factors. One is the phrasing for measuring leisure travel satisfaction. The present study refers to "travel for purposes other than work or education", while De Vos and Witlox (2016) refer to "travel to the most recent leisure activity". Although there is considerable overlap in the meaning of both phrasings, they can however have somehow different connotations to the respondent. Another reason for the difference in leisure travel satisfaction between the two studies could be related to the geographical and built environment characteristics of the two city regions. For example, leisure travel satisfaction is higher for urban residents of Oslo because they can access both city facilities as well as surrounding nature easily by foot and public transport, whereas for suburban residents accessing city facilities is usually more troublesome and in many suburban areas access to the surrounding forest areas is also difficult with travel modes other than the private car.

The present study further investigates how commute satisfaction is shaped by urban form, by using travel behavior as mediator. Trip duration seems to be the most important explanatory factor of how urban form affects commute satisfaction. Compact urban forms are found to enable significantly shorter trip durations. Both short distances to city center and high local neighborhood densities are found to reduce trip duration to main occupation. It seems that compact-city and urban densification policies, which aim at increasing densities and limiting distances to facilities by controlling sprawl, will result in shorter trip durations and thus higher travel satisfaction for more residents.

The other aspect of travel behavior examined in the study is commute mode choice. Commute mode choice is also found to substantially mediate the relationship between urban form and travel satisfaction. Walking is found to be promoted by compact urban forms and is a major travel mode in such areas, used by more than 30% of compact urban residents. Walking is found to be by far the most pleasant travel mode. The car, on the other hand, is the major travel mode in sprawled areas, used by about 50% of the suburbanites for commuting. The car is found to be by far the least pleasant travel mode. These significant differences in the mediating effect of travel mode explain the differences in travel satisfaction between urban forms in addition to the aforementioned mediating effect of trip duration. In line with other studies (e.g. St-Louis et al., 2014), walking, cycling, and train are found to be more pleasant than public transport and car. However, most other studies report that public transport is the least pleasant of all travel modes (e.g. De Vos et al., 2016). Strong car restrictions found in Oslo (tolls, limited parking, and limited driving space) possibly make the car less pleasant than in other contexts. At the same time, the high quality of public transport in Oslo may make it more pleasant

than in other contexts. These outcomes on mode choice are encouraging for urban sustainability, as compact-city policies being applied facilitate walking, cycling, and use of public transport, while at the same time they limit car use. It should also be noted that in addition to reducing greenhouse gases and increasing travel satisfaction, a modal shift from private motor vehicles to walking, cycling, and public transport, enabled by compact urban forms, has important health benefits for diabetes, cardiovascular disease, and respiratory disease (Stevenson et al., 2016). One issue that emerged through the outcomes of this study is the importance of bicycle infrastructure and policies for both modal share and travel satisfaction of bicycles. The bicycle is not as widely used in Oslo as in some other European cities (e.g. Dutch or Danish cities). As the qualitative interviews indicate, bicycle infrastructure in Oslo is limited, which makes its use as a main travel mode less safe, less pleasant, and therefore more limited. Relevant policies and infrastructure should be developed in order to increase bicycle modal share as well as bicycle travel satisfaction.

5.2. Implications for urban sustainability

Compact urban development has long been recommended to promote environmental sustainability (CEC, 1990; Newman and Kenworthy, 1999; Williams et al., 2000; Næss, 2001; Rérat, 2012; OECD, 2018) due to its lower car dependency (see Section 2.1), less energy-requiring housing types (Høyer and Holden, 2001; Brown and Wolfe, 2007) and lower encroachments on ecosystems and farmland (Beatley, 2000; EEA, 2006). Moreover, recent studies in Oslo metropolitan area indicate higher neighborhood satisfaction and higher satisfaction with personal relationships among residents of compact than low-density suburban neighborhoods (Mouratidis, 2017, 2018a) and no difference between compact-city and suburban residents in overall SWB (Mouratidis, 2019). There thus seem to be important synergies between environmental and social dimensions of urban sustainability. Whereas some early critics of urban densification policies claimed that such land use planning would be detrimental to the economy (e.g. Gordon and Richardson, 1989), several later studies have concluded that urban containment is less costly for society (Burchell et al., 1998) and beneficial for economic prosperity (e.g. Cervero, 2001). Together, the above-mentioned evidence provides strong support of urban containment policies, at least in cities that are not already overly dense.

However, as also noted by one of the interviewees of the present study, compact and central urban neighborhoods have increasingly become unaffordable for low- and medium-income population groups. Fueled by changes in residential preferences and neoliberal urban policies, substantial gentrification has taken place in many European cities (Musterd et al., 2017). Although some authors hold urban densification as favorable to combat social inequality (Power, 2001), recent development in Oslo and several other European suggest that much more active governmental housing policies must be in place to prevent the compact areas offering the highest neighborhood satisfaction and travel satisfaction from becoming increasingly the segregated neighborhoods of the rich.

5.3. Future research

This study has certain limitations which can be addressed by future research studies. First, although trip duration and travel mode seem to be the most important mediators between urban form and travel satisfaction according to quantitative and qualitative results of this article, additional mediating factors can be explored by future research such as trip safety, traveling alone or with company, and trip surroundings. These are already established predictors of travel satisfaction, but have not been assessed as mediators between urban form and travel satisfaction. Second, as the present study is based on one city region, it would also be useful to test such conceptual approaches in other contexts to provide a more nuanced understanding of the topic. Third, personal characteristics such as personality traits and human values may vary across space, thus influencing the spatial distribution of life satisfaction (Jokela et al., 2015; Morrison and Weckroth, 2018). Future research could examine whether these characteristics would affect the relationship between urban form and travel satisfaction. Fourth, future studies can examine this topic further by assessing the role of the city size in travel satisfaction. This could be done by analyzing data from multiple city regions. The city size has been linked to SWB (Berry and Okulicz-Kozaryn, 2011; Morrison and Weckroth, 2018), but can also play a role in travel satisfaction by affecting trip durations, used travel modes, as well as the social context (e.g. crowdedness, safety).

6. Conclusion

This article provides new empirical insights into the impact of compact versus lower-density urban forms on travel satisfaction. Previous literature has not adequately examined how urban form and its physical attributes affect travel satisfaction and how travel behavior mediates this relationship. Another contribution of the article is that it is based on a mixed-methods approach combining statistical analysis and modeling with analysis of in-depth qualitative interviews. Such an approach is rarely found in the field of travel satisfaction research and qualitative studies are extremely scarce. The input from the qualitative interviews in this study offers additional support and more detailed explanations of the causal mechanisms examined by the quantitative analysis.

The outcomes of the study address two main research questions. (1) Compared with residents of sprawled suburbs, compact-city residents seem to be significantly more satisfied with their travel to their main occupation as well as with their travel for leisure. Higher local neighborhood density and proximity to city center are found to positively influence both commute satisfaction and leisure travel satisfaction. (2) The main factors that explain why compact urban forms promote satisfaction with the commute are trip duration and travel mode. Compact urban dwellers enjoy significantly shorter trip duration, on average, compared with sprawled suburban dwellers, and this greatly contributes to higher travel satisfaction. In addition, compact urban dwellers, on average, use more pleasant travel modes to commute to work or education. They walk, which is found to be the most pleasant travel mode, to a much higher extent than suburban dwellers. Suburban dwellers, on the other hand, use the car, which is found to be the least pleasant

travel mode, to a much higher extent than urban dwellers.

The study's outcomes suggest that compact-city policies enabling short distances and moderately high densities, and therefore short trip durations, active travel, and less car dependency, can promote travel satisfaction. Attention should be paid however to housing policies so that the benefits of compact central urban areas, such as high travel satisfaction and neighborhood satisfaction, are not enjoyed only by the most privileged.

Acknowledgements

This study is based on data collected for the research project "Compact City or Sprawl? The Role of Urban Form in Subjective Well-Being". The project was supported by the Norwegian University of Life Sciences.

Appendix A

See Tables A1–A4.

Table A1
Compact neighborhoods of the study.

Neighborhood name	Neighborhood type	Population density (persons/ha)	Distance to city center (km)	Main building type	Land uses	Sample size (persons)
St. Hanshaugen	Compact	203	2.3	Apartment block	Mixed	62
Grønland	Compact	205	1.0	Apartment block	Mixed	100
Frogner A	Compact	135	2.8	Apartment block	Mixed	8
Frogner B	Compact	306	2.6	Apartment block	Mixed	20
Majorstuen A	Compact	221	3.1	Apartment block	Mixed	57
Majorstuen B	Compact	247	2.9	Apartment block	Mixed	35
Sagene	Compact	267	3.5	Apartment block	Mixed	57
Torshov	Compact	135	3.3	Apartment block	Mixed	71
Grünerløkka A	Compact	171	1.5	Apartment block	Mixed	53
Grünerløkka B	Compact	244	2.3	Apartment block	Mixed	72

Note: Total sample size for compact neighborhoods N = 535.

Table A2
Sprawled neighborhoods of the study.

Neighborhood name	Neighborhood type	Population density (persons/ha)	Distance to city center (km)	Main building type	Land uses	Sample size (persons)
Holmen	Low-density suburban	30	6.0	Detached house	Separate	13
Lofthus	Low-density suburban	50	5.6	Detached house	Separate	17
Hellerud	Low-density suburban	44	7.7	Detached house	Separate	33
Holmenkollen A	Low-density suburban	24	10.5	Detached house	Separate	19
Korsvoll	Low-density suburban	31	6.5	Detached house	Separate	11
Nordberg	Low-density suburban	26	5.8	Detached house	Separate	13
Stovner	Low-density suburban	36	13.1	Detached house	Separate	7
Nordstrand	Low-density suburban	38	8.4	Detached house	Separate	14
Hauketo	Low-density suburban	32	10.1	Detached house	Separate	12
Rykkinn	Low-density suburban	26	19.2	Detached house	Separate	44
Bærums Verk	Low-density suburban	42	17.7	Detached house	Separate	38
Stabekk	Low-density suburban	26	8.6	Detached house	Separate	11
Asker	Low-density suburban	23	25.0	Detached house	Separate	41
Nesøya	Low-density suburban	14	21.6	Detached house	Separate	45
Ski	Low-density suburban	22	26.4	Detached house	Separate	42
Oppegård	Low-density suburban	27	17.6	Detached house	Separate	51
Drøbakk	Low-density suburban	38	36.0	Detached house	Separate	26
Bjørnemyr	Low-density suburban	26	46.0	Detached house	Separate	35
Ytre Enebakk	Low-density suburban	22	32.6	Detached house	Separate	32

Note: Total sample size for sprawled neighborhoods N = 504.

Table A3
Other neighborhoods of the study.

Neighborhood name	Neighborhood type	Population density (persons/ha)	Distance to city center (km)	Main building type	Land uses	Sample size (persons)
Frogner C	Inner-city mixed	94	2.8	Mixed	Mostly separate	17
Skøyen	Inner-city low density	46	4.2	Mixed	Separate	16
Grefsen	Suburban mixed	97	7.6	Mixed	Separate	26
Vålerenga	Inner-city mixed	130	2.5	Mixed	Mostly separate	52
Etterstad	Inner-city medium density	72	3.2	Apartment block	Separate	14
Høyenhall	Inner-city low density	52	4.4	Detached house	Separate	13
Østenjø	Suburban mixed	55	6.4	Mixed	Separate	16
Holmenkollen B	Suburban mixed	60	10.6	Mixed	Separate	20
Hovseter	Suburban mixed	76	7.4	Mixed	Separate	22
Ullevål	Inner-city mixed	57	4.0	Mixed	Separate	22
Berg	Inner-city low density	35	4.6	Detached house	Separate	20
Kringsjå	Suburban mixed	73	6.8	Mixed	Separate	12
Vestli	Suburban medium density	126	13.6	Apartment block	Separate	3
Tokerud	Suburban mixed	81	13.8	Mixed	Separate	16
Holmlia	Suburban mixed	62	10.8	Mixed	Separate	13
Blystadlia	Suburban mixed	88	20.0	Mixed	Separate	23

Note: Total sample size for other types of neighborhoods N = 305.

Table A4
Comparison of sociodemographic characteristics.

Sociodemographic variables	Survey respondents (N = 1344) Mean	Population Mean
Age (for aged 18 or older)[1]	50.16	46.30
Unemployed[2]	2.50%	3.50%
Living with partner/spouse[1]	61%	48%
Non-Norwegian[1]	9%	21%
Adjusted household income (1000 s NOK)[1]	642.2	582.98
Household size (persons)[1]	2.22	1.94
Number of children in household[1]	0.54	0.46
Household with children[1]	32%	26%
Respondent is female[1]	53.40%	50.30%
Respondent has college degree or higher[2]	79%	47%

[1] Population mean refers to the counties of Oslo and Akershus.
[2] Population mean refers to Oslo municipality.

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