17th International Conference on Travel Behaviour Research
July 14 - 18, 2024 – Vienna, Austria

Children's Active Mobility, Physical Activity and Well-being

Juliane Stark[1], Sandra Wegener[1], Valerie Batiajew[1], Shun Su[1], Elisabeth Huter[1], Reinhard Hössinger[1]

[1]Institute for Transport Studies, University of Natural Resources and Life Sciences Vienna, Peter Jordan St. 82, 1190 Vienna, Austria, juliane.stark@boku.ac.at

Keywords (3-5 words): active mobility, well-being, children

1. Introduction

1.1.Starting point

Declining rates of physical activity among children are reported all over the world. Recent systematic analyses from 168 countries show that the prevalence of insufficient physical activity has increased in high-income countries (Guthold et al., 2018). Young age groups, in particular, do not engage in enough physical activity. According to the World Health Organization (WHO), 83% of schoolchildren in Austria do not meet the recommendations for health-promoting physical activity levels (Maier et al., 2017). This is consistent with global estimates, based on 2010 figures, that 81% of adolescents (aged 11-17 years) do not fulfill the recommendations (WHO, 2018). As children get older, they become even less active (Ramelow et al., 2015; Riddoch et al., 2004). These trends are also reflected in an increasingly passive mobility behavior: the share of trips made by Austrian students on foot decreased from 35% to 25% between 1995 and 2014, while they are more often driven (from 17% to 25%) (Tomschy et al., 2016). Furthermore, it is alarming that the relative number of students with overweight respectively obesity has risen steadily since 2014 (Felder-Puig, 2023). Only 35% of Austrian adolescents report no physical complaints (Knechtsberger & Schwabl, 2016). Studies show also a sharp increase in psychological symptoms among children and adolescents in Austria. The incidence of depressive symptoms and sleep disorders has increased five- to tenfold compared to previous studies (Pieh et al., 2021). There is also a continuous deterioration in life satisfaction among older students since 2014 (Felder-Puig, 2023).

1.2. Active mobility and well-being

Low physical activity associated with everyday mobility is also thought to have negative effects on children's physical, psychological, cognitive, social, and economic well-being ("five domains of well-being," Waygood et al., 2020; Waygood et al., 2015); however, the mechanisms behind these associations have not been adequately explored (Westman et al., 2020). In particular, research in the psychological domain is limited; one indicator in this domain is subjective well-being. This involves feelings, happiness, and the extent to which a person is satisfied with his or her life in general (Bergstad et al., 2011; Bullinger, 2009).

Research on adults suggests that people who use active transportation tend to be happier and more satisfied (De Vos et al., 2013; De Vos, 2019). The results seem to be similar for children (Waygood et al., 2017, Stark et al., 2018; Waygood & Cervesato, 2017). As a dimension of children's overall well-being, mobility-related well-being likely influences their overall life satisfaction (Waygood et al., 2019; Khaleghi & Kato, 2023) and may have a positive impact on attention in school and academic performance (Westman et al., 2017). The relationships between mobility behavior, physical activity, attitudes, and well-being requires further research.

1.3. Objective and innovation

This paper is based on the project "*TRA:WELL* – transport and well-being" (2022-2024), a national research project funded by the Austrian Federal Ministry of Education, Science and Research. It presents the results related to the project's main objective, namely, to explore how active mobility (complementary to physical activity) is related to children's well-being. The data for our analysis was provided by a comprehensive survey in 2023 among 12 to 14 years old children. The key innovation of this paper is its empirical rigor in two respects: (i) active mobility, physical activity and wellbeing were measured repeatedly on seven consecutive days, and (ii) active mobility and physical activity were measured by means of a diary, in which the realized behavior was to be reported retrospectively. Both innovations allow for a much stronger test of the aforementioned relationships compared to studies, which ask the individuals only once for subjective self-assessments of their generalized behavior. The paper is structured as follows: Section 2 describes data and methods. First results of the descriptive-explorative data analysis and models are shown in Section 3. In Section 4, the paper closes with a discussion of key findings and study limitations.

2. Data and methods

2.1. Sample and study design

Our sample includes 75 children in the 6th and 7th grade of three classes of three different secondary schools of a comparable type. School A and B are located in the densely built 19th district of Vienna, Austria; it is very well accessible with metro, tram and bus. School C is in Korneuburg, a small town of 14,000 inhabitants north of Vienna in Lower Austria. Data was collected in April and May 2023 by means of an online-survey.

2.2.Questionnaire

The questionnaire consisted of two parts: (i) a person and household section to be filled in only once as well as (ii) a diary-like section to be filled repeatedly for seven consecutive days.

The *person and household section* was divided into three subsections: (i) me and my home, (ii) my mobility tools, and (iii) my health. In the *diary section*, we asked what time the child

got up, if it was out of the house on that day, what it did until it started the first trip and how strenuous these activities were according to three intensity levels *[very exhausting, a little exhausting, not exhausting]*. For each trip, children reported start and end time, origin and destination address, weather conditions, who contributed to the mode choice, and which modes were used *[walking, bicycle, scooter, e-scooter/e-bike, public transport, in a car, other]*. For each travel mode, we further asked the queried duration as well as the accompaniment. At each trip's destination we further asked for the main activity type (similar to trip purpose) and how much time was spent there, again divided into three activity intensity levels as mentioned above.

In addition to the trip section, each reporting day included an 'evening section' with several questions related to well-being: quality of sleep last night and how the child felt physically and mentally today; responses were provided on a five-part scale *[very bad, rather bad, partly-partly, rather good, very good]*. Furthermore, we asked various dimensions of well-being: How did you feel today, thinking about: (1) school, (2) family & home, (3) friends, (4) other people, (5) feelings & moods, (6) satisfaction with yourself, appearance, (7) self-determination, (8) Instagram, Snapchat, TikTok, (9) exercise, sports, (10) food; responses were provided on a five-part scale with labelled endpoints *[very poor - very good]*. These dimensions emerged from the workshops with the children and largely coincide with the well-being dimensions in the KIDSCREEN questionnaire (The KIDSCREEN Group Europe, 2006; Ravens-Sieberer et al., 2005 & 2014). Two concluding questions asked if the child had enough time for him/herself and whether this was a typical day *[no, partly-partly, yes]*.

2.3.Data preparation and analysis

During data input, all of the trip origins and destinations were encoded with GPS coordinates. The coordinates served in turn to retrieve the objective door-to-door travel time and distance for each trip with four different modes (walking, cycling, transit, car) using online journey planning services (Verkehrsauskunft Österreich; Google Maps directions service). Variables gathered at the trip-level or trip stage-level were aggregated at the person-day level: for each travel mode we calculated total duration, time share, and a dummy indicating whether this mode was used on a particular day; the physical activity variables were treated analogously. This procedure yields a person-day level dataset with panel structure.

In a first step of data analysis we applied a Principal Component Analysis (PCA) to our set of well-being variables to in order to explore the underlying latent dimensions of children's well-being. In a second step, we analyzed the effects of active mobility (AM) and physical activity (PA) on children's well-being using two regression approaches: ordinary linear regression, which assumes the same baseline level of well-being for all respondents (one global intercept), and a mixed linear model with random intercept, which respects the panel structure of our data.

The key advantage of the mixed model is that it analyzes the effects of AM/PA on well-being on a day-to-day level. Significant effects can be interpreted as causal effects with high certainty, since possible confounding effects of other personal characteristics are controlled and eliminated. A disadvantage, however, is that long-term effects of our hypothesized predictors are removed as well. Comparing the result of both the ordinary and mixed model allows to decompose the effects of AM and PA on well-being into those, which take place immediately on a day-to-day level, and those which happen on a larger time scale. It should however be noted that the latter effects may be entangled with confounding effects as mentioned above. This requires a cautious interpretation.

3. Results

3.1. Sample characteristics

Overall, 71 out of 75 children (68% female) took part in the survey. They reported a total of 1,265 trips on 465 reporting days. The number of children is equally distributed across the three sites. Please note that the number of reporting days is sufficient for a robust analysis, but the number of children is rather low and some personal characteristics are distributed unbalanced (such as gender), so that interpretations are always in regard to the studied target group.

3.2. Mobility characteristics

The average daily trip frequency is 2.7 per person and 3.0 per mobile person. It corresponds well to the results reported for the age group 6 to 14 in the latest national travel survey in Austria 2013/2014 (2.7 and 3.1 trips per person and mobile person, Tomschy et al., 2016). Figure 1 shows the modal split of the sample on trip-level, which means that each trip is assigned to a single "main mode" using a common hierarchical allocation scheme (BMVIT, 2011). 36.8% of trips were actively traveled. Public transport accounts for a similarly high proportion (36.1%). These results correspond approximately to those reported in the latest national travel survey.

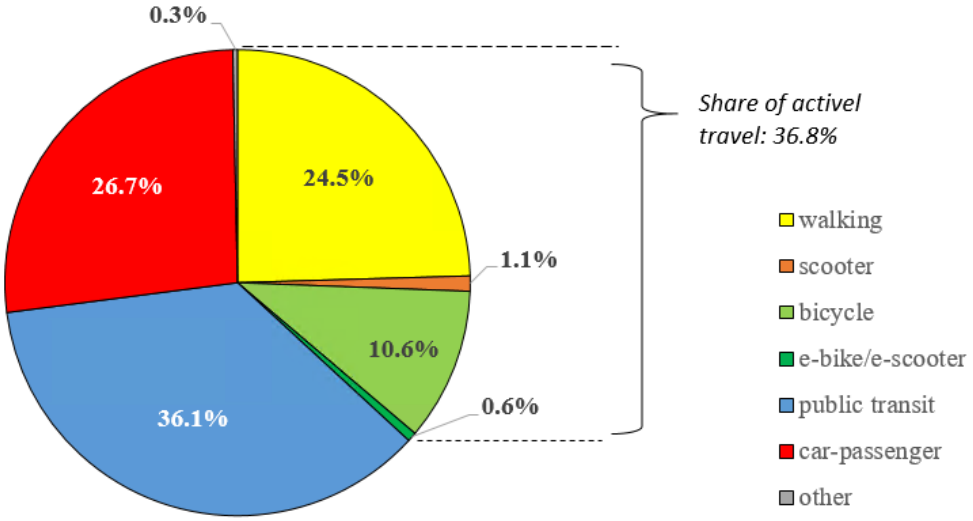

Figure 1: Modal split, n=1,235 trips

3.3. Dimensions of children's well-being

We used a Principal Component Analysis to extract the independent dimensions of children's well-being from our set of related variables. Two variables ("social media" and "enough time for yourself") were eliminated from the outset due to their isolated position in the covariance structure. From the remaining 11 variables, we extracted two principal components that collectively account for 60% of the total variance (Table 1). The 1st component shows high loadings of those 7 variables which relate to specific aspects: school, family & home, friends, other people, satisfaction with oneself & appearance, emotions & moods, self-determination. The 2nd component seems to represent an overarching condition with high loadings of sleep quality as well as physical and mental feelings. Interestingly, the variable "movement & exercise, sport" falls almost perfectly between these two components, which indicates an equally moderate relationship with both of them.

Table 1: Factor loadings of well-being (WB) variables on two dimensions derived from PCA Model 1/2 = with/without variable "movement/exercise, sport", respectively (n=465)

	Model 1		Model 2	
WB-related variables on reporting day level	PC1	PC2	PC1	PC2
Quality of sleep last night	0.104	0.859	0.111	0.861
How did you feel physically today?	0.178	0.857	0.183	0.853
How did you feel mentally today?	0.396	0.720	0.407	0.731
WB in relation to school	0.636	0.093	0.637	0.083
WB in relation to family and home	0.616	0.336	0.622	0.343
WB in relation to friends	0.654	0.172	0.657	0.172

WB in relation to other people	0.660	0.184	0.663	0.180
WB in relation to your emotions, moods	0.770	0.271	0.773	0.271
WB in relation to satisfaction with yourself, appearance	0.784	0.144	0.789	0.149
WB in relation to your self-determination	0.743	0.222	0.743	0.214
WB in relation to movement/exercise, sport	*0.450*	0.391		
Eigenvalues	3.809	2.471	3.646	2.330
Explained variance	0.346	0.225	0.365	0.233
Cumulative variance	0.571		0.598	

3.4. Effects of active mobility and physical activity on children's well-being

The effects stated in the header were analyzed at the reporting day level using ordinary linear regression (OLM) and a mixed linear model (MLM). The results are shown in Table 2:

Table 2: Results of an OLM and MLM regressing children's well-being on active mobility and physical activity on a day-to-day level (n=465)

Response variable: WB related to movement/exercise, sport	OLM		MLM with random intercept	
Independent variables	estimate	t value	estimate	t value
intercept	4.017	74.119	4.048	48.681
undirected walking trip(s) performed	0.481	3.253	0.461	3.648
cycling trip(s) performed	0.467	3.913	0.181	1.425
share of exhausting activities	0.014	3.575	0.014	3.463
share of little exhausting activities	0.008	2.008	0.008	2.303
Model diagnostics	R^2: 0.093 F value: 11.66		conditional R^2: 0.467 marginal R^2: 0.064	

An important limitation to be noted is that the two broad well-being dimensions derived from the PCA are not affected by the daily levels of active mobility (AM) and physical activity (PA); only "well-being in relation to movement/exercise, sport" is significantly affected. The OLM reveals 4 predictors, two of which relate to each of the two domains AM and PA. Table 3 shows correlations between these predictors; there is only one moderate positive correlation between undirected walking trips and "little exhaustive" activities, which means that the predictors are largely independent from each other.

Table 3: Correlations among model predictors (n=465)

Independent variables	1	2	3
1. undirected walking trip(s) performed			
2. cycling trip(s) performed	-0.039		
3. share of exhausting activities	0.010	0.054	
4. share of little exhausting activities	-0.010	0.137	0.045

The t values of the 4 predictors in the OLM are at comparable levels, which means that their explanatory power is similar. Nonetheless, there are some differences: In case of PA, the time share of activity engagement matters (as expected). In case of AM, however, the mere engagement (yes or no) turned out to yield more predictive power than the corresponding duration. A possible reason is the difference in the distribution: undirected walking trips and cycling trips are only performed by few (8 and 13% of reporting days, respectively), whereas 68% of days see some form of exhaustive activities, 37% even on level 3.

A comparison of the OLM and MLM shows that 3 of 4 predictors yield a similar or even higher predictive power in the random intercept model, which means that the predictor affects the response variable immediately on a day-to-day level. Cycling is an exception: it is the strongest predictor in the OLM, but its effect decreases and becomes insignificant in the MLM. The reason is that only relatively few children (17 out of 71) engaged in cycling at all, and those tend to have a higher baseline well-being level, which is captured by the random intercept in the MLM (see Figure 2). The other 3 predictors show a broader distribution (25 with undirected walking trips, 70 with some form of exhaustive activities, thereof 54 with level 3).

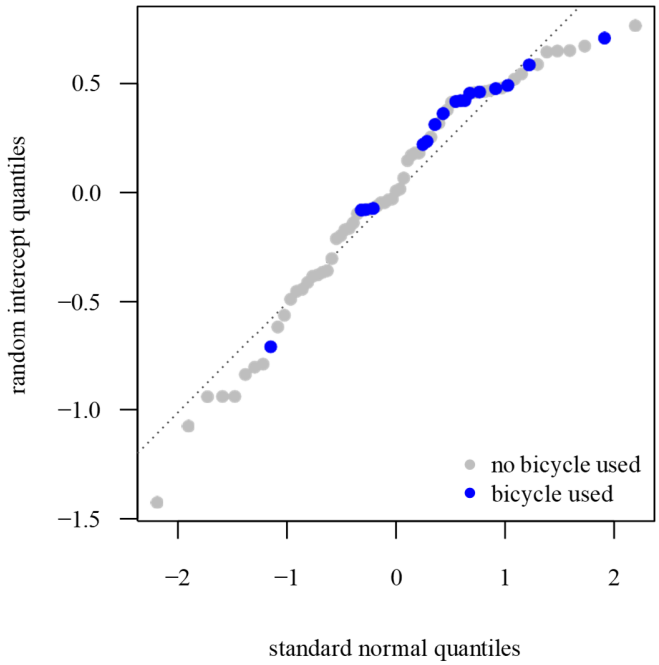

Figure 2: Distribution of random intercepts of cyclists and non-cyclists in the MLM

4. Discussion

In this study we analyzed the effects of active mobility (AM) and physical activity (PA) on children's well-being (WB) with two innovation aspects: (i) a diary-based measurement of

AM and PA, and (ii) a panel dataset with 7 repeated observations per individual, which allows to analyze the relationships on a day-to-day level.

With regard to the concept of children's WB, we identified 3 components. Two of them are broad dimensions represented by several variables: (i) an overarching condition and (ii) a more specific view on various aspects of well-being. These dimensions do not seem to respond to the daily levels of AM and PA. The 3rd dimension relates to "movement/exercise, sport". It is related to the former two dimensions in equal distance, and also to AM and PA. It may be interpreted to take an interim stage, which mediates the effects of AM and PA to the WB-domain. It is plausible that the use of active travel modes and high activity levels might not necessarily impact *all* WB-dimensions, particularly in the group of adolescents, whose well-being is more likely to fluctuate during (oncoming) puberty compared to the relatively more stable WB-patterns of adults (Larsen & Richards, 1991).

According to our model, two aspects of AM affect children's well-being in the aforementioned sense: the conduction of *undirected* walking trips and cycling trips. Directed walking trips (getting from A to B) have no positive effect on well-being. This confirms our experience that walking, although widespread, is neither perceived as real means of transport nor as a physical exercise by most students, but as an ordinary means to get around. Both effective forms of AM are rare: undirected walking and cycling trips occurred on 8 and 13% of reporting days, respectively. From this follows that the overall effect of AM on WB is limited despite its statistical significance. This might also explain why it is the mere occurrence of these mobility forms (rather than the duration of engagement) which bears the strongest effect on well-being.

The effect of undirected walking trips is similar in both models without and with random intercept. It means that such trips affect children's well-being immediately on a day-to-day level, while there might be little or no lasting effect. Cycling is different: its daily effect is positive but insignificant. However, regular cyclists (17 out of 71 children in our sample) exhibit a higher baseline level of well-being, which might indicate a long-term positive effect on a larger time scale. Accounting for this effect in addition to the daily effect makes cycling the strongest predictor of well-being in our model. However, this requires further research, because confounding effects of other personal characteristics could fake such an effect.

The daily time share of exhaustive activities (along with the level of exhaustion) has also a positive effect on well-being besides active mobility. Exhaustive activities are much more widespread than undirected walks and cycling trips, from which can be concluded that they contribute relatively more to children's wellbeing. Our analysis shows that AM and PA are largely independent of each other. Insofar, it makes sense to promote both types of activity, because they will not substitute each other but add up to the total effect.

References

Bergstad, C. J., Gamble, A., Gärling, T., Hagman, O., Polk, M., Ettema, D., et al. (2011). Subjective wellbeing related to satisfaction with daily travel. *Transportation*, 38, 1-15.

Bullinger, M. (2009). Well-being in children and adolescents - The state of the art in research and conceptual background. *Zeitschrift für Gesundheitspsychologie*, 17(2), 50-55. doi:10.1026/0943-8149.17.2.50.

De Vos, J., Schwanen, T., Van Acker, V., Witlox, F. (2013). Travel and subjective wellbeing: a focus on findings, methods and future research needs. *Transport Rev.,* 33 (4), 421–442. doi:10.1080/01441647.2013.815665.

De Vos, J. (2019). Satisfaction-induced travel behaviour. *Transportation Research Part F: Traffic Psychology and Behaviour,* 63, 12–21. doi:10.1016/j.trf.2019.03.001.

Ettema, D., Gärling, T., Eriksson, L., Friman, M., Olsson, L.E., Fujii, S. (2011) Satisfaction with travel and subjective well-being: Development and test of measurement tool. Transportation Research Part F 14 /2022) 167-175

Felder-Puig, R. (2023). Gesundheit und Gesundheitsverhalten von österreichischen Schülerinnen und Schülern - Ergebnisse des WHO-HBSC-Survey 2021/22 [Health and health behaviors of Austrian schoolchildren - results of the WHO-HBSC survey.]. Bundesministerium für Soziales, Gesundheit, Pflege und Konsumentenschutz (BMSGPK) (Ed.).

Guthold, R., Stevens, G.A., Riley, L.M., Bull, P.F.C. (2018). Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1.9 million participants. *The Lancet Global Health*, 6 (10), e1077-e1086. doi:10.1016/S2214-109X(18)30357-7.

Khaleghi, M., & Kato, H. (2023). Children's non-school trips, travel-related subjective well-being, and life satisfaction: Evidence from young adolescents in rural Japan. Transportation Research Part a-Policy and Practice, 169. doi: 10.1016/j.tra.2023.103591.

Knechtsberger, A., Schwabl, T. (2016). Jugend-Trend-Monitor 2016. Vienna: marketagent.com - Digitale Markt- und Meinungsforschung. [Digital market and opinion research]. Presentation from 14.04.2016. Retrieved from: www.businessart.at/images/doku/jugend_trendmonitor_april_2016.pdf (15 Nov. 2018).

Maier, G., Friedrich T., Felder-Puig, R. (2017). HBSC Factsheet 01 - Das Bewegungsverhalten österreichischer Schülerinnen und Schüler: HBSC Ergebnisse 2014. [HBSC Factsheet 01 - The Physical Activity Behavior of Austrian Students: HBSC Results 2014.]. Federal Ministry for Health and Women (Ed.).

Mitra, R. (2013). Independent mobility and mode choice for school transportation: A review and framework for future research. *Transport Reviews*, 33, 21–43. doi:10.1080/01441647.2012.743490.

Pieh, C., Plener, P.L., Probst, T., Dale, R., Humer, E. (2021). Mental Health in Adolescents during COVID-19-Related Social Distancing and Home-Schooling. doi:http://dx.doi.org/10.2139/ssrn.3795639.

Ramelow, D., Teutsch, F., Hofmann, F., Felder-Puig, R. (2015). Gesundheit und Gesundheitsverhalten von österreichischen Schülern und Schülerinnen - Ergebnisse des WHO-HBSC-Survey 2014. [Health and health behavior of Austrian pupils – results of the WHO-HBSC-Survey 2014.], Vienna.

Ravens-Sieberer, U., Gosch, A., Rajmil, L., Erhart, M., Bruil, J., Duer, W., Auquier, P., Power, M., Abel, T., Czemy, L., Mazur, J., Czimbalmos, A., Tountas, Y., Hagquist, C., Kilroe, J., The European KIDSCREEN Group. (2005). KIDSCREEN-52 quality-of-life measure for children and adolescents. *Expert Review of Pharmacoeconomics & Outcomes Research,* 5 (3), 353-364.

Ravens-Sieberer, U., Herdman, M., Devine, J., Otto, C., Bullinger, M., Rose, M., Klasen, F. (2014). The European KIDSCREEN approach to measure quality of life and well-being in children: development, current application, and future advances. *Qual Life Res*, 23:791–803. doi: 10.1007/s11136-013-0428-3.

Riddoch, C.J., Andersen, L.B., Wedderkopp, N., Harro, M., Klasson-Heggebo, L., Sardinha, L.B., Cooper, A. R., Ekelund, U. (2004). Physical activity levels and patterns of 9- and 15-yr-old European children. *Medicine & Science in Sports & Exercise*, 36(1), 86-92. doi:10.1249/01.MSS.0000106174.43932.92.

Stark, J., Meschik, M., Singleton, P.A., Schützhofer, B. (2018). Active school travel, attitudes and psychological well-being of children. *Transportation Research Part F*, 56, 453–465. doi:10.1016/j.trf.2018.05.007.

The KIDSCREEN Group Europe. (2006). The KIDSCREEN Questionnaires – Quality of life questionnaires for children and adolescents. Handbook. Lengerich: Pabst Science Publishers.

Tomschy, R., Herry, M., Sammer, G., Klementschitz, R., Riegler, S., Follmer, R., Gruschwitz, D., Josef, F., Gensasz, S., Kirnbauer, R. (2016). Österreich unterwegs 2013/2014. Ergebnisbericht zur österreichweiten Mobilitätserhebung. Vienna: Federal Ministry for Transport, Innovation and Technology.

Verkehrsauskunft Österreich (VAO) (n.d.): https://www.verkehrsauskunft.at/

Westman, J., Friman, M., Olsson, L. E. (2020). Travel and child wellbeing: The psychological and cognitive domains. In: *Transport and Children's wellbeing*. Elsevier. ISBN 978-0-12-814694-1, pp. 41-59.

Westman, J., Olsson, L., Gärling, T., Friman, M. (2017). Children's travel to school: satisfaction, current mood, and cognitive performance. *Transportation*, 44(6), 1365–1382. doi:10.1007/s11116-016-9705-7.

Waygood, O., & Cervesato, A. (2017). Transport and child well-being: Case study of Quebec City. *Journal of Transport and Health*, 5, S98. doi:10.1016/j.jth.2017.05.256.

Waygood, E.O.D., Friman, M., Olsson, L.E., Taniguchi, A. (2017). Transport and child well-being: An integrative review. *Travel Behaviour and Society*, 9, 32-49. doi:http://dx.doi.org/10.1016/j.tbs.2017.04.005.

Waygood, E., Friman, M., Olsson, L., Mitra, R. (2020). Introduction to transport and children's wellbeing. In: Transport and Children's wellbeing. Elsevier. ISBN 978-0-12-814694-1, 1-17.

Waygood, E., Friman, M., Olsson, L., Taniguichi, A. (2015). Transport and Child Well-Being. *Journal of Transport & Health*, 2(2), S62-S63. doi:10.1016/j.jth.2015.04.599.

Waygood, E.O.D., Friman, M., Taniguchi, A., & Olsson, L.E. (2019). Children's life satisfaction and travel satisfaction: Evidence from Canada, Japan, and Sweden. *Travel Behaviour and Society*, 16, 214-223, doi:10.1016/j.tbs.2018.04.004.

WHO (2018). Global action plan on physical activity 2018–2030: More active people for a healthier world, ISBN 978-92-4-151418-7.