Working Paper

A Multi-disciplinary Synthesis of the Literature on Elderly Mobility

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ABSTRACT

Mobility in later life is a key determinant. Even though it has been studied by scholars in medicine, sociology, transport and urban planning, related findings are indeed exploited within each discipline and thus potential spillovers have not been pointed out yet. Contributing to filling this gap, this study is a multidisciplinary systematic review aiming at informing researchers and academics in these disciplines for the impacts of elderly mobility on dimensions of well-being and quality of life. We searched for peer-reviewed articles in a general electronic database (Scopus) published from 2010-2019. Sixty-two studies met the inclusion criteria, with 42 of the papers coming from medicine, 9 from sociological literature, 9 from transport and 1 from urban planning literature. There are substantial variations and, in some cases, overlaps in the terminology used, the toolkit of measures and the resulting effects. Since the topic of elderly mobility is indeed multidisciplinary, fruitful collaborations of the researchers both theoretically and empirically is highly encouraged in the future.

KEY WORDS **–**mobility; elderly; healthy ageing; multidisciplinary; systematic review

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1. Introduction

Together with decreasing birth rates, advances in medicine and technology are pushing up life expectancy and are leading to ageing populations in both developed and developing countries (Cao and Zhang, 2016).

The projections of the international organizations such as the OECD and the United Nations reveal a quantitative representation of the issue. In OECD countries, the population share of people over 65 years old will reach 25.1% in 2050, from 7.7% in 1950 (OECD, 2015). The projections of the UN (2015) show that the percentage share of people aged 60 or over will increase in all continents by 2050. The countries of Latin America and Caribbean are listed first with respect to the percentage change of the elderly population. Although Europe will not face the highest percentage change (from 24% in 2015 will reach 34% by 2050) it has already the oldest population with a median age of 42 years which is expected to reach 46 by 2050 (UN/DESA, 2015).

The aim of this paper is on the one side to review systematically the literature on the effects of mobility on the life of the elderly people within different research fields (medicine, sociology, transport and urban planning) and on the other side to illustrate the differences and similarities of their approach by bringing closer the results. The focus is on studies in developed countries.

In particular, this study aims to give answers to the following research questions:

1. What is the language used for the elderly mobility by scientists in medicine, sociology, transport and urban planning?
2. What are the effects of mobility on dimensions of well-being and quality of life (QoL) of the older people by scientists in medicine, sociology, transport and urban planning? What is the evidence found in the literature during the last 10 years?
3. What is the toolkit used to measure mobility within the disciplines and which measure is used for every effect studied?

To the best of our knowledge, this is the first multidisciplinary study to stress the effects of mobility on the life of the elderly people. The advantage of a

multidisciplinary approach is that it could reveal aspects of the topic that otherwise remain hidden (Murray, 2015) since the perspective of each discipline is substantially different. The paper is organized as follows: in section 2 we describe the framework of the research topic, in section 3 it is analysed the methodology used, in section 4 there are presented the results, and finally section 5 concludes and proposes further research directions.

2. Healthy aging

Nowadays, scientists and policymakers have shown growing attention for the issue of the ageing population, whereas in the past it was neglected. From an economic perspective, beyond raising concerns about the economic support for an increasing unproductive segment of the population, this concept mostly implies that a variety of implications will emerge for the health care (Abdullah et al., 2018; Aguiar and Macário, 2017) and pension system, the society and the general provision of consumer products and services (Metz, 2000) and environmental issues (Aguiar and Macário, 2017). Furthermore, this population group represents an important source of consumption (Banister and Bowling, 2004) and raises several questions for its contribution to the economy. This argument is supported by Mackett (2015) and shows that older people contribute to the society through expenditure in shops, employment, voluntary work, childcare and taxation.

The approach of active ageing was first developed by the World Health Organization in 2002 (WHO, 2018). The WHO (2007) defines active ageing as the process of optimizing opportunities for health, participation and security in order to enhance the QoL as people age. However, there is no consensus on what is implied by active ageing (Johnson et al., 2017). It is related to a number of factors including both material and social and which can play a role on the individual's feelings and behaviour during the age phase of life (WHO, 2007). Active ageing was supported until 2015 when it was replaced by the approach of healthy ageing. Actually, this new framework prioritizes the enhancement of functional ability by actively encouraging all relevant sectors to work together (WHO, 2018).

Successful ageing can be supported by initiatives that enhance mobility (Musich et al., 2018). Mobility of the elderly people is widely studied by researchers and scientists in medicine, sociology, transport and urban planning and there is consensus that mobility is crucial in later life. However, researchers within the various disciplines uncover a diversity of effects for the elderly people and the findings are mainly exploited in an intradisciplinary way.

3. Methods

3.1. Study selection

The systematic review was conducted by searching the relevant articles in electronic databases. We used the keywords 'mobility AND elderly', 'mobility AND older', 'mobility AND old', 'mobility AND later life', 'mobility AND senior', 'mobility AND ageing', 'mobility AND aging'. We selected specifically these words because they are quite broad in order to retrieve articles deriving from the focus disciplines. The search was conducted in April 2019 only within the titles of the articles. The idea behind this method is that we aim to get studies that are exclusively examining elderly mobility and not just referring to it at some points in the article.

3.2. Criteria of Inclusion

The studies were reviewed by one of the authors and the cases of doubt were resolved collectively. For this paper the following criteria for inclusion were used:

1) Only studies written in English were included.
2) Peer-reviewed studies and published in academic journals were included while letters and reviews were excluded.
3) The focus group of the study should be community dwelling, non-institutionalized or population based elderly people.
4) Although the definition of the older person is vague, we decided that the minimum age of 60 years is enough to characterize the participants'as old.
5) Although the studies about elderly mobility in developing countries are a few, they are excluded from this review because the context is quite different from the developed countries.

6) There are many studies on the determinants of mobility or what are the obstacles that the elderly people face with respect to their everyday mobility but these do not respond to our research questions and thus were excluded. In this study, the papers that examined the effect of mobility on older peoples' life were only taken into consideration.

Using the above criteria, the steps of the research strategy are described in Figure 1. Totally, 2416 articles were retrieved from the one electronic library (Scopus). After including the English studies only, 2334 papers remained, where 525 out of them were included after title scanning. Excluding for duplicates leaves 313 possible studies for selection. In addition to the titles, we went through the abstracts and the remaining articles reached 271. After full paper screening, 62 articles were included as relevant to respond to our three research questions mentioned earlier (in the introduction).

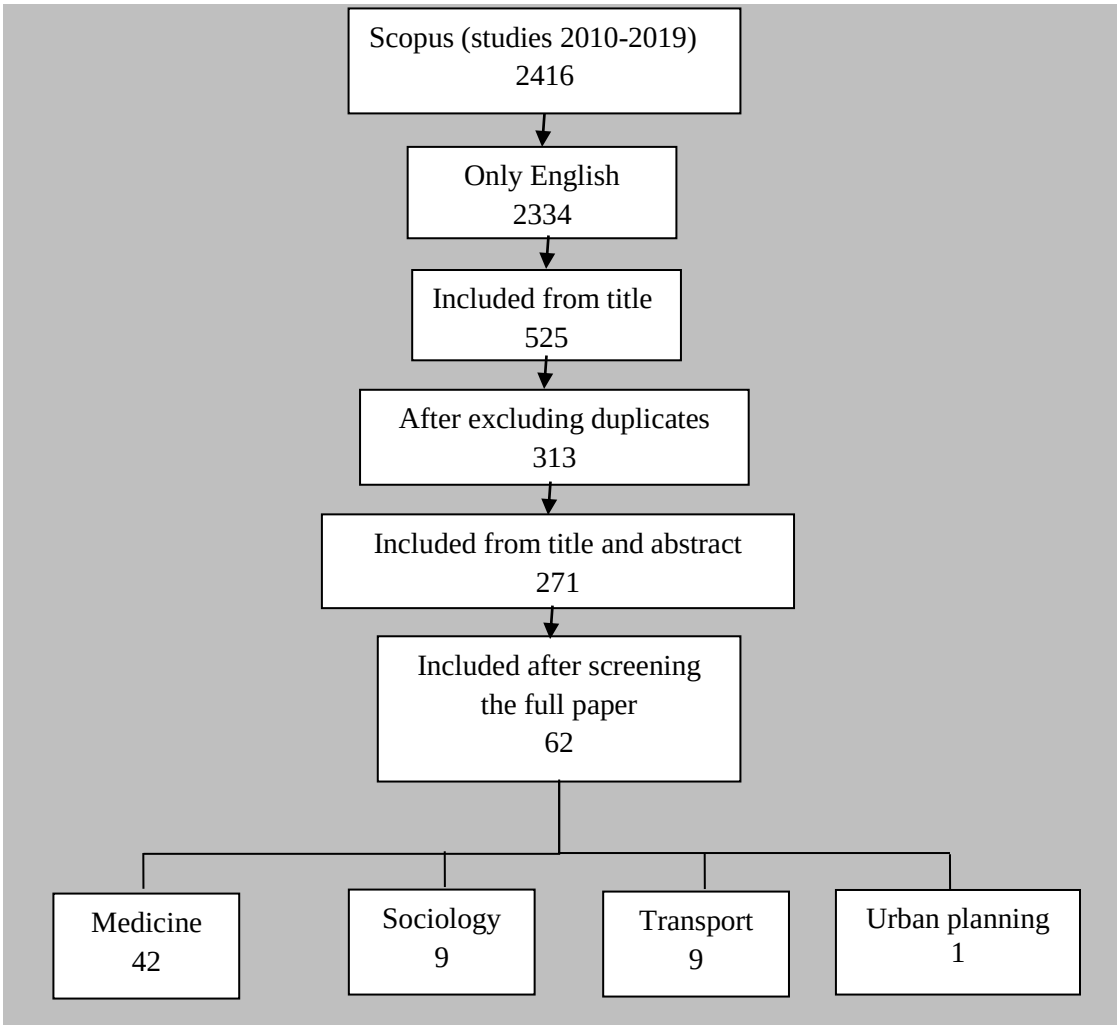

Figure. 1: Search strategy process

4. Results

4.1. RQ1: What is the language used for elderly mobility by scientists in medicine, sociology, transport and, urban planning?

In the last 10 years, elderly mobility is a topic studied mostly in medicine comparing the number of studies that come from this field with sociology, transport and urban planning literature. Specifically, 42 medicine studies were retrieved by the searching methodology, 9 sociological, 9 transport and 1 urban planning. Although the scientists of the four disciplines study elderly mobility, our review revealed the differences and similarities between them with respect to the terminology used. Table 1 illustrates the findings for each discipline separately.

Obviously, in medicine there is a wider variety of terms (9 terms) compared to sociology, transport and urban planning literature. This cannot be considered a strange result as it goes in line with the number of studies collected (42 studies). On the opposite side stands the urban planning literature where the terminology is rather limited (1 term) and this goes again in accordance with the studies found (1 study). Articles coming from sociology and transport bring quite similar number of terms and can be classified between the two extremes.

Table 1: Terminology of elderly mobility in medicine, sociology, transport and urban planning

Discipline / Terminology	Medicine	Sociology	Transport	Urban Planning
mobility	18	2	4	1
life-space mobility	7	2		
functional mobility	1			
baseline mobility	1			
out-of-home mobility	1	1		
physical mobility	3			
mobility difficulty	1			
mobility impairment	2	2		
mobility limitation	8	1		
mobility resources		1	1	
transport mobility			1	
transportation mobility			2	
discretionary mobility			1	
Total number of different terms	9	6	5	1
Total number of studies	42	9	9	1

As regards the quality of the collected vocabulary, given that mobility is a more generic term, it is mostly used in all disciplines. However, the meaning is quite heterogeneous among the researchers not only of the same discipline but also of different disciplines. In table 3 (later in this study), it is described analytically the way mobility is conceived by researchers. Specifically, the language in medicine betrays that the scope of the research is basically to investigate the capability of the elderly to be mobile or to assess the hardship to be mobile. However, there are some studies (see table 1) that make use of life-space and out-of-home mobility which gives a sense of connection of being mobile with the environment.

Sociological terminology of elderly mobility is closer to medicine compared to the two remaining disciplines. More, in sociology it is found a study about the mobility resources which is closer to transport research language. Particularly, transport scientists use mobility in such a way that it seems to be interwoven with the means of transport that facilitates the movement on space. Finally, in urban planning literature mobility is the term used and has also the sense of transport.

An inclusive multidisciplinary term for elderly mobility should consider all the dimensions of movement, i.e. ability to be mobile, the extension of movement on the physical space and the means selected for the movement.

4.2. RQ2 What are the effects of mobility on dimensions of well-being and QoL of the older people by scientists in medicine, sociology, transport and urban planning? What is the evidence found in the literature during the last 10 years?

The answer given to this research question is quite heterogeneous across and within the disciplines. In table 2, we present briefly the findings and in this section we comment them. This table was created as follows: for every study included in this systematic review the effect of mobility was isolated and categorized to the four specific disciplines. After, for every discipline the effects were classified in four groups, according to the items included in the Active Ageing Index (European Commission, 2013), such as Health (including physical activity), Independent Living, Social Inclusion and the concept of Well-being/QoL.

- ✓ *Medicine*

Health

Many of the included medical studies on elderly mobility indicate that mobility has implications on various health conditions. The correlation of mobility with lower levels obesity is found among physically mobile elderly while the direction of the causality is not clear, most probably it is a two way relationship (Asp et al., 2017). Furthermore, mobility is associated with hypertension, diabetes (Nascimento et al., 2015) and urinary incontinence (Fritel et al., 2013) and longitudinal studies that would clarify the connection are missing in the literature.

The results on mobility and cognition show that there is a link between the two parts in some studies while in other not. Life-space mobility restrictions (Silberschmidt et al., 2017) together with visuomotor (Cohen et al., 2016), fast walking performance (Tian et al., 2016) and other mobility measures such as walking time, balance and stand chair tests (Demnitz et al., 2017) are indicators for the cognitive decline that will follow. With age increase, the connection increases slightly signalling that the effect is attenuating for the older elderly (Demnitz et al., 2018). However, usual gait speed appears to have a two directional relationship with executive function (Tian et al., 2016) but longitudinally little support is found opening a research gap to be verified for larger time periods (Donoghue et al., 2018).

Falls among the elderly population are quite often. Medicine scientists are studying the most accurate measures to predict them. Although mobility is recognized to be an accurate predictor (Musich et al., 2018b; Topuz et al., 2014), the test used to measure it can affect its credibility. The TUG test provides good results in Wang et al. (2016) while Mulasso et al. (2016) suggest not to be consulted since it is not significantly associated with falls. The results of the mobility tests can be used also to classify the disabilities (Heiland et al., 2016) and even mortality (Olaya et al., 2018; Frith et al., 2017; Kang et al., 2017; Bergland et al., 2017; Mackey et al., 2016; Mackey et al., 2014; Katja et al., 2014; Verghese et al., 2012).

It is demonstrated that depression in later age is a consequence of low levels of mobility rather than the age itself (Picazzo-Palencia, 2016; Lee et al., 2012a; Lee et al., 2012b). Going one step further, Polku et al. (2015) study the different dimensions

of depression and their relations with life-space mobility, confirming their association but not the temporal dimension.

A very important finding to keep in mind is that the burden to the inpatient care will increase as a result of the mobility limitations (Kabiri et al., 2018; Ensrud et al., 2017; Kozakai et al., 2013).

Independent living

Mobility can be crucial to the maintenance of independence (Diem et al., 2018), mood (Kaspar et al., 2015) and adjustment of personal goals (Saajanaho et al., 2016).

Well-being/QoL

Although it is not clear whether higher life-space mobility goes in parallel with QoL, for the case of the elderly people it is true irrespectively of their health conditions (Rantakokko et al., 2016; Rantakokko et al., 2013). Shafrin et al. (2017) found that the near elderly persons (aged 50 to 69) with better mobility reported higher QoL. Leisure engagement is restricted if the older people have fears of falling, use mobility devices, and need help with bathing and/or cleaning (Nilsson et al., 2015).

The term Health Related Quality of Life (HRQoL) is used in medicine to define the QoL of an individual which results from its health status, experience of disease, and process of natural aging (Kawecka-Jaszcz et al., 2013, p.1). The HRQoL of the elderly is substantially affected by mobility and falls (Törnvall et al., 2016; Davis et al., 2015a). Gender differences can be observed. In a 12 month study in Vancouver (Davis et al., 2015a), men appeared to have decreased HRQoL over time regardless of their mobility condition but women only because of mobility difficulties. The elderly people, in order to value highly their mental and physical health it should be accompanied by the ability to satisfy their everyday needs relying on executive function, e.g. walking (Forte et al., 2015). Fagerström and Borglin (2010) make a clear distinction between functional ability and mobility and investigate separately and jointly their effect on HRQoL. When mobility coexisted with functional ability, the mobility effect was found to dominate on HRQoL.

Mobility is found to be related not only with HRQoL but with well-being as well. Davis et al. (2015b) propose well-being as a more inclusive reference indicator for policymakers because appears to be related with factors that HRQoL does not, such as the cognition.

- ✓ *Sociology*

Researchers in sociology study the role of mobility on the facilitation of social inclusion and contribution to well-being and QoL.

Social Inclusion

Yet the role of mobility is important in promoting social engagement, either as a direct impact or as an indirect consequence of life satisfaction, even for unimpaired elderly people (Li and Loo, 2017; Rosso et al., 2013). In cases of mobility difficulties, the social networks constitute a dominant factor in keeping the elderly connected to the society and thus, contribute to successful ageing (Litwin and Levinson, 2018).

Well-being/QoL

Mobility contributes to well-being (La Grow et al., 2013; Gagliardi et al., 2010; Ziegler and Schwanen, 2011) and it should be considered in a multidimensional manner. There are intermediate factors that can affect either negatively the relationship such as the functional capacity (La Grow et al., 2013) or positively through feelings of independence and social connections with other people (Ziegler and Schwanen, 2011). However, it is supported that physical mobility can be substituted by other mobilities that can mitigate this decline (Ziegler and Schwanen, 2011). Freedman et al. (2017) considered well-being as: life satisfaction, emotional and somatic wellbeing. All three elements were associated negatively with mobility impairments but somatic well-being more with respect to the other.

Mobility as an experience might seem a lot more for the older people. Franke et al. (2018) interviewed a group of Canadian elderly to understand their perceptions. They reported to maintain a sense of self, being resourceful, be open to engagement, engage in superficial contact, experience social capital, access

transportation, leave the immediate neighbourhood and face affordability. Some years earlier, Mollenkopf et al. (2011) conducted a study in order to explore the potential changes in perceptions about mobility by the elderly between 1995 and 2005. They found stability of the perceptions through the studied period and spotted seven thematic categories. According to this classification, mobility has the sense of an emotional experience, human need, movement and participation in the natural environment, social need, expression of personal autonomy and freedom, source of stimulation and diversion and reflective expression of the person's remaining life force.

- ✓ *Transport*

Health

Mobility through the lens of transport literature is seen to strongly affect the health performance in later life. Walking at least 500 meter daily, the use of private car and social engagement has implications both to physical and mental self-reported health (Chiatti et al., 2017).

Furthermore, the elderly who used walking for transport might have lower depressive symptoms than those who did not (Choi and DiNitto, 2016) and also lower mental health has been found among those living far from the closest bus stop and never using public transport (Chiatti et al., 2017).

Musselwhite (2017) studied qualitatively the discretionary mobility. The participants in this study responded that discretionary mobility adds to their health and well-being. For instance, a female driver reported: 'Can take a headache away driving along that road.'

Social Inclusion

Mobility problems can be a drawback for outdoor exercise, chatting with neighbours, and longer distance activities (Chen et al., 2015). Although older people describe transportation mobility as vital for their independence (Adorno et al., 2018) and activity engagement, more research would shed light on these relationships (Zeitler and Buys, 2015).

Well-being/QoL

Since the formation of well-being and QoL by transport mobility has recently entered in transport research there are only a few studies. Ravulaparthy et al. (2013) propose that the elderly who engage in out-of-home activities, socialize, and enjoy better mobility also report higher levels of subjective well-being leading to a better QoL.

From a theoretical point of view, Musselwhite and Haddad (2010) underline that through mobility the elderly fulfil their basic needs, the need for independence, control, status and roles, and the need to travel for its own sake. Covering this range of needs leads to higher levels of QoL.

Hjorthol (2013) builds on the framework of having, loving and being to define well-being. The transport resources do not cover the mobility needs of the elderly resulting in unfulfilled welfare dimensions mainly in activities related to the 'loving' and 'being' dimensions.

- ✓ *Urban planning*

The urban planning literature on the effects of elderly mobility is limited and the one study retrieved investigates the impact of mobility on loneliness. All the other studies coming from the urban literature were excluded because of little relatedness. In general, most researchers from urban planning are interested in the difficulties that the elderly face on their efforts to move.

Social Inclusion

The study of van den Berg et al. (2016) using data from the Netherlands supported that the use of different transport modes (bicycle, car and public transport) works against loneliness. In this study, mobility has been measured by asking the participants whether or not they use a car, a bicycle and public transport.

Table 2: Effects of mobility in later life by discipline

A.	***Effect***	***Medicine Studies***
HEALTH	Obesity	Asp et al., 2017
	Hypertension and diabetes	Nascimento et al., 2015
	Urinary Incontinence	Fritel et al., 2013
	Cognition	Demnitz et al., 2018; Donoghue et al., 2018; Demnitz et al., 2017; Silberschmidt et al., 2017; Cohen et al., 2016; Tian et al., 2016
	Falls	Musich et al., 2018;Mulasso et al., 2016; Wang et al., 2016; Topuz et al., 2014
	Risk of disability	Heiland et al., 2016
	Mortality	Olaya et al., 2018; Frith et al., 2017; Kang et al., 2017;Bergland et al., 2017; Mackey et al., 2016; Mackey et al., 2014; Katja et al., 2014;Verghese et al., 2012
	Depression	Picazzo-Palencia, 2016; Lee et al., 2012a; Lee et al., 2012b
	Dimensions of depression	Polku et al., 2015
	Hospitalization and inpatient care	Ensrud et al., 2017; Kozakai et al., 2013
	Long-Term Health	Kabiri et al., 2018
INDEPENDENT LIVING	Independent living	Diem et al., 2018; Portegijs et al., 2014
	Mood	Kaspar et al., 2015
	Personal Goals	Saajanaho et al., 2016
WELL-BEING/ QoL	HRQoL	Törnvall et al., 2016; Davis et al., 2015a; Forte et al., 2015; Fagerström and Borglin, 2010
	QoL	Shafrin et al., 2017; Rantakokko et al., 2016;
	HRQoL& Well-being	Davis et al., 2015b
	Leisure engagement	Nilsson et al., 2015
B.	***Effect***	***Sociological Studies***
SOCIAL INCLUSION	Social engagement	Li and Loo, 2017; Rosso et al., 2013
	Social networks	Litwin and Levinson, 2018
WELL-BEING/ QoL	QoL	La Grow et al., 2013
	Well-being	Ziegler and Schwanen, 2011; Gagliardi et al., 2010
	Well-being and life satisfaction	Freedman et al., 2017
	Maintaining a sense of self, being	Franke et al., 2018
	Emotional experience, basic human need, movement and participation in the natural environment, social need, expression of personal autonomy and freedom, source of stimulation and diversion and expression of the person's remaining life force.	Mollenkopf et al., 2011

C.	*Effect*	*Transport Studies*
HEALTH	Health and well-being	Musselwhite, 2017
	Physical and mental health	Chiatti et al., 2017
	Depressive symptoms	Choi and DiNitto, 2016
SOCIAL INCLUSION	Social equity	Adorno et al., 2018
	Social activity trips	Chen et al., 2015
	Community engagement	Zeitler and Buys, 2015
WELL-BEING/ QoL	Well-being	Ravulaparthy et al., 2013
	Activities for welfare and well-being	Hjorthol, 2013
	QoL	Musselwhite and Haddad, 2010
D.	*Effect*	*Urban Studies*
SOCIAL INCLUSION	Loneliness	van den Berg et al., 2016

4.3. RQ3 What is the toolkit used to measure mobility within the disciplines and which measure is used for every effect studied?

In order to map the measures used to assess mobility impact on elderly QoL, we built-up a scheme divided in four columns (Table 3). It includes the type of mobility studied by the scientists, the measure(s) used to evaluate it, the investigated effect and the wider category this finding falls (level of impact). This table is a mapping of the evidence on R.Q.3. for all the disciplines and in the same time it works as a guide for further research steps. Since mobility can be a determinant factor for health, independent living, social inclusion, well-being and QoL table 3 depicts for every type of defined mobility in the disciplines which of these items is studied in the past 10 years. In this way, it opens a wide range of research gaps to be covered by future studies.

- ✓ *Medicine*

From a medical point of view, elderly mobility is given the dimension of corporeal capability to be active/mobile, evaluated either by medical tests or by

self-reported answers. The first can provide more objective assessment with respect to the second, which depends highly on the individuals' judge.

There are several tests that have been used in order to evaluate the level of mobility of the elderly people. Time up and go test (TUGT) was used by nine studies and we could say that it is the tool that it is mostly found. It is the time (in seconds) it takes for the study participant to rise from a chair (with armrests), walk three meters quickly but safely, turn and walk back to the chair and sit down. In some cases, it was the only measure while in other it coexisted with other assessment tools.

However, there are also other measurement methods as well. Five studies used the walking ability to cross various distances, i.e. 2.44, 4, 6 and 10 meters, assessed by the time needed to complete the task. A more complex version of the walking test is the Walking While Talking Test (WWT) which requires the coordination of two functions simultaneously. The picture of the evaluation of mobility is completed by considering the performance of the elderly evaluated by the steps made daily, gait, balance or lower-extremity function.

More recently, the mobilisation of technology with the use of GPS devices in combination with information from travel diaries gives space to continuous and objective registration of mobility. Finally, one study created an index for mobility, consisting of the fear of falling and the potential use of mobility device.

Many studies assessed the elderly mobility subjectively using a variety of questions addressed to the elderly people with predetermined choices to select or open responses. A particular example is that of the life-space mobility that is measured using Baker et al. (2003) methodology. The elderly were asked to indicate:

1. the greatest distance attained with the help of assistive devices or another person if needed (maximal life-space),
2. life-space attained without help from any assistive devices or another person (independent life-space),
3. indicating life-space attained using the help of assistive devices if needed but not the help of another person (life-space using assistive devices and
4. distance, frequency, and independency of movement in a range of 0-120 (composite score)

Finally, the self-reported mobility measures may contain questions about the difficulties in walking, climbing stairs and use of public transportation.

✓ *Sociology*

In sociology, elderly mobility is basically measured by self-reported answers to questions addressed to the studies' participants in order to analyse implications on social inclusion, well-being and QoL. Such a methodology hides the possibility either of underestimation or overestimation of the magnitude of mobility. In such cases might also apply all the drawbacks related to self-reported answers. In two qualitative studies mobility is defined more broadly as:

- The fundamental physical capacity to move (Mollenkopf et al., 2011).
- A broader understanding of mobility than movement through physical space(Ziegler and Schwanen, 2011).

✓ *Transport*

In transport literature, elderly mobility is often measured in terms of transport means, i.e. walking, car, public transport, etc., trip frequency and types of activities. In most of the included studies, self-reported answers to assess mobility are used. GPS tracking found in one study (Zeitler and Buys, 2015) which if combined with travel diaries can be considered a mixed approach with more reliable results.

✓ *Urban*

In the unique urban planning study included, mobility is conceived in terms of transport used and the information is again extracted by self-reported answers leaving room for bias in measurements.

Table 3: Mobility measures and effects by discipline

Medicine			
Type of mobility	**Measure of mobility**	**Level of impact**	**Effect (Study)**
life-space mobility	Measure à la Baker et al. (2003)	Health	Cognition (Silberschmidt et al., 2017), Mortality (Mackey et al., 2016; Mackey et al., 2014),Dimensions of depression (Polku et al., 2015)
		Independent living	Sense of autonomy in outdoor activities(Portegijs et al., 2014)
		Well-being/ QoL	QoL (Rantakokko et al., 2016; Rantakokko et al., 2013)
functional mobility	Maximal walking speed (WS; m/s), i.e., walking as fast as possible without running, over 10 meters in simple task and in two dual-task conditions.	Health	HRQoL(Forte et al., 2015)
baseline mobility	Timed Up-and-Go Test (TUGT): the time (in seconds) it takes for the study participant to rise from a chair (with armrests), walk three meters quickly but safely, turn and walk back to the chair and sit down.	Health	Cognition (Donoghue et al., 2018)
out-of-home mobility	GPS tracking and completion of daily diaries	Independent living	Mood (Kaspar et al., 2015)
physical mobility	Two questions: 'Can you walk up stairs without difficulty (for example getting on a bus or a train)?' and 'Can you take a short walk (about five min) at a reasonably fast pace?'. The participant was considered having physical mobility if he/she answered yes to both.	Health	Obesity (Asp et al., 2017)
	Basic Mobility: Participants were asked if their health condition cause them difficulties in two levels of activities e.g. 1) going from one room to another or taking a shower and 2) preparing hot food or going shopping.	Health	Depression (Picazzo-Palencia, 2016)
	Physical mobility index: Normally, because of a health problem, do you have difficulty in 1. Running, lifting weight, doing sports or doing heavy work?2. Pushing a table or doing a home repair?3. Going up a steep hill or stairs? 4. Stooping or kneeling?5. Walking about 100 m?	Health	Hypertension and diabetes(Nascimento et al., 2015)
mobility difficulty	Mobility Index: questions about fear of falling and use of a mobility device.	Independent living	Leisure engagement (Nilsson et al., 2015)
mobility impairment	Mobile application measuring steps per day.	Health	Long-Term Health (Kabiri et al., 2018)
	Timed 6-m walk test, TUG test, and a test measuring the time taken to get up from a chair and sit down again five times without using the arms.	Health	Urinary Incontinence (Fritel et al., 2013)
mobility limitation	Two screening questions focused on difficulties with walking or climbing stairs.	Health	Falls (Musich et al., 2018)

mobility limitation	Self-reported difficulty in walking without special equipment use, walking 0.25 miles walking 10 steps without stopping; stooping etc. Mobility limited were classified the participants who reported to have difficult in any of the activities.	Health	Mortality (Frith et al., 2017)
	4-m walking test and the TUGT. Participants scoring in the top 20% on the TUGT or in the slowest 20% for the 4-m walking test were defined as having mobility limitation.	Health	Mortality (Kang et al., 2017)
	Two tests: the one-leg balance stand was measured by the nurse, asking the participant to stand as long as possible, up to 60 s, first on one leg then the other. This was then repeated, and the best overall score was used.	Health	Risk of disability (Heiland et al., 2016)
	Self-reports of perceived difficulty in walking 2 km and climbing one flight of stairs without resting. Individuals who reported no difficulty at all in either activity were defined as having intact mobility and those who reported at least some difficulty in one or both of these activities were defined as having.	Health	Hospitalization and inpatient care (Kozakai et al., 2013)
	An eight-item assessment of mobility limitations enquired about limitations in the different tasks e.g. standing continuously for 15 min, squatting, etc.	Health	Depression (Lee et al., 2012a; Lee et al., 2012b)
	Self-reported difficulties in walking 2 km, climbing stairs, climbing one flight of stairs and in using public transportation.	Independent living	Personal Goals (Saajanaho et al., 2016)
mobility	Walk speed was calculated for each participant by measuring the time in seconds to walk 6 meters at a usual pace expressed as m/s. Walk speeds were divided into three categories: good (≥0.9 m/s), intermediate (>0.6 to <0.9 m/s), and poor (≤0.6 m/s).	Independent living	Maintenance of independence (Diem et al., 2018)
	Participants reported the overall difficulties they had experienced in the previous 30 days in 15 different situations related to mobility.	Health	Mortality (Olaya et al., 2018)
	Walking time over a clearly marked 8-foot (2.44 m) course. Balance: the time (in seconds) a balance position was held, with an upper cut-off of 30s. Chair stands tests: participants were asked to sit on an armless chair, rest their feet on the floor and to fold their arms across their chest. Participants were instructed to stand up and sit down without using their arms five times, and to do so as quickly as possible.	Health	Cognition (Demnitz et al., 2018)

mobility	Walking time over a clearly marked straight-line 4-meter course. Balance: the time (in seconds) a balance position was held, with an upper cut-off of 60s. Chair stands test: participants were asked to sit on a chair and fold their arms across their chest. Participants were then instructed to stand up and sit down without using their arms five times.	Health	Cognition (Demnitz et al., 2017)
	Distance walked in 6 minutes without sitting and without the use of a walker or the help of another person (a cane may be used).	Well-being/ QoL	QoL (Shafrin et al., 2017)
	Short Physical Performance Battery (SPPB): performances of standing balance, walking, and sit-to stand. Each component is rated out of four points, for a maximum of 12 points, categorized as poor (score 0–3), intermediate (score 4–9), or good (score 10–12).	Health	Hospitalization and inpatient care (Ensrud et al., 2017)
	Timed Up and Go test (TUGT)	Health	Mortality (Bergland et al., 2017), Falls (Mulasso et al., 2016; Wang et al., 2016),HRQoL (Törnvall et al., 2016; Davis et al., 2015a), Cognition (Cohen et al., 2016;)
	Two tests were used: usual gait speed to the nearest 0.1 second measured on a 6-meter course and a 400 m walk test for the 400 m fast walk time.	Health	Cognition (Tian et al., 2016)
	Short Physical Performance Battery (SPPB): performances of standing balance, walking, and sit-to stand. Each component is rated out of four points, for a maximum of 12 points; a score < 9/12 predicts subsequent disability.	Health	HRQoL& Well-being (Davis et al., 2015b)
	Timed Up and Go test, Timed Chair Stand test, Functional Reach test, One-Leg Balance test, and lower limb muscle strength.	Health	Falls (Topuz et al., 2014)
	Participants were asked about ability to walk indoors, outdoors, and climb stairs. The response options were categorized as 'yes, without difficulties', which scored 0, and 'has difficulties/ not able/ needs somebody to help', which scored 1. A composite score (range 0–3) was calculated for the three mobility dimensions.	Health	Mortality and social activity(Katja et al., 2014)
	Walking While Talking Test (WWT): participants walked on a computerized walkway while reciting alternate letters of the alphabet (e.g., a, c, e), paying equal attention to walking and talking to avoid task prioritization.	Health	Mortality, fraility and disability(Verghese et al., 2012)

mobility	Three tests assessed the following: i) participants' ability to open a bottle; ii) ability to rise from a chair without using their arms; and iii) ability to pick things up from the floor. Two items assessed participants' ability to walk up and down a flight of stairs without difficulty and their ability to walk a distance without stopping (1 km, 300-400 metres, 100-200 metres, 50 metres, and indoors).	Health	HRQoL (Fagerström and Borglin, 2010)
Sociology			
Type of mobility	**Measure of mobility**	**Level of impact**	**Effect (Study)**
life-space mobility	Not defined	Well-being/ QoL	Maintaining a sense of self, being resourceful, openness to engagement, engaging in superficial contact, experiencing social capital, accessing transportation, leaving the immediate neighbourhood and facing affordability *(*Franke et al., 2018*)*
	Modified Baker et al., 2003 (eliminating level 2)	Social Inclusion	Social engagement (Rosso et al., 2013)
mobility	Single self-report question asking: 'How well are you able to get around?, with responses made on a 5-point Likert-type scale ranging from 1 'Very poor' to 5 'Very well'.	Well-being/ QoL	QoL *(*La Grow et al., 2013*)*
	A broader understanding of mobility than movement through physical space.	Well-being/ QoL	Well-being (Ziegler and Schwanen, 2011)
mobility impairment	Two questions: 1) whether the senior has any difficulty walking 1 km and 2) whether the senior has any difficulty climbing several flights of stairs. The participants were asked about the use of mobility auxiliaries, including walking stick, travel device, manual, and electric wheelchair.	Social Inclusion	Social engagement and life satisfaction (Li and Loo, 2017)
	Respondents were asked to report whether in the last seven days they had limited strength or movement in their hips, legs, knees, or feet and, if so, on how many days did this impairment limit their activities. Then, a severity measure was created that reflected the number of days an individual was limited by their lower body impairments.	Well-being/ QoL	Well-being and life satisfaction (Freedman et al., 2017)
mobility limitation	Difficulties that the respondent reported having experienced in each of ten functions such as walking metres, climbing one flight of stairs without resting and lifting or carrying weights over ten pounds/five kilo grams.	Social inclusion	Social networks (Litwin and Levinson, 2018)

mobility resources	Driving car, use of public transport and performing physical activity (none, light, moderate/regular).	Well-being/ QoL	Well-being (Gagliardi et al., 2010)
out-of-home mobility	The fundamental physical capacity to move.	Well-being/ QoL	Emotional experience, basic human need, movement and participation in the natural environment, social need, expression of personal autonomy and freedom, source of stimulation and diversion and expression of the person's remaining life force. (Mollenkopf et al., 2011)
Transport			
Type of mobility	**Measure of mobility**	**Level of impact**	**Effect (Study)**
discretionary mobility	Travel for its own sake.	Health/Well-being	Health and well-being (Musselwhite, 2017)
mobility	Amount of travel undertaken.	Well-being/ QoL	Qol (Musselwhite and Haddad, 2010)
	Walking 500 m or more, access to private car, use of private car, bus stop distance from home and use of public transport	Health	Physical and mental health (Chiatti et al., 2017)
	Transport resources to access to activities (having, loving, being).	Well-being/ QoL	Activities for welfare and well-being (Hjorthol, 2013)
	GPS tracking.	Social Inclusion	Community engagement (Zeitler and Buys, 2015)
mobility resources	Persons were asked how (other than driving) they got to places outside their home during the preceding month responding yes = 1 or no = 0: 1)getting a ride from a family member, friend, or someone paid to help; 2) walking or using a wheel chair or scooter, 3) taking public transportation, 4) using a van or shuttle service provided by the place where the sample persons lived, 5) using a van or shuttle service for seniors or disabled persons, 6) taking a taxi, and 7) using other means	Health	Depressive symptoms (Choi and DiNitto, 2016)
transport mobility	The physical or mental ability to move around safely and independently, whether inside or outside the home.	Well-being/ QoL	Well-being (Ravulaparthy et al., 2013)
transportation mobility	Not defined	Social Inclusion	Social equity (Adorno et al., 2018)
	Trip frequency and classified into three types: outdoor exercise, chatting with neighbours, and longer distance activities.	Social Inclusion	Social activity trips (Chen et al., 2015)
Urban planning			
Type of mobility	**Measure of mobility**	**Level of impact**	**Effect (Study)**
mobility	The participants were asked whether they use a car, a bicycle and public transport or not.	Social Inclusion	Loneliness (van den Berg et al., 2016)

5. Conclusions and further research

The ageing of the worldwide population indicates that targeted research is crucial to give directions to policymakers on how effectively promote healthy ageing. Elderly mobility is a multidisciplinary research topic and should be treated in that way by researchers. It is a promising research field and our approach points to this direction.

The study of elderly mobility varies in medicine, sociology, transport and urban planning literature. Medical researchers are interested on the impact of mobility as a physical ability on the performance of daily tasks and how it affects dimensions of well-being and QoL. The toolkit for mobility measurement is rich and contains both objective tests of functional ability and subjective self-assessments through answers to targeted questions. The aim of the studies is basically to explore impacts on health conditions and to a lesser extent maintenance of independence and enhancement of well-being and QoL.

The sociological literature shows a mixed landscape. Mobility is given either a broader meaning of movement on the physical space, the means used to move or difficulties and impairments in movement. The systematic review shows that mobility is found to be beneficial for health, independent living and social inclusion in later life. Sociological literature lies in the middle of medicine and transport studies.

In transport research, mobility is connected to the means that facilitate the movement and it is apparent to the measurement tools. Although the literature finds health, social inclusion and QoL implications, it is rather in its infancy and substantial empirical research is essential. Urban planning scientists have not included actively this topic in their research agenda. Both urban and multidisciplinary approach studies are highly encouraged for the future.

For the future, there are open a lot of research gaps that can be derived from table 3.Since elderly mobility is measured with various ways as shown in table 3, comparison of two or more tools with respect to the same effect could tell us whether the measure selection is sensitive to the results. After the research contribution of this study, it is possible to create a multidisciplinary measurement for elderly mobility. Table 3 illustrates the candidates for this position. Finally, for each type of mobility could be explored the effect on health, independence, social inclusion, well-being and QoL. The third column of this table is the guide for this step.

Our systematic review has some strengths and some limitations. As regards the first ones, to the best of our knowledge, this is the first multidisciplinary approach to the topic of elderly mobility. Presenting in the same time the results of the four disciplines is a strong motivation for future collaboration. The research gaps identified here could become the beginning of fruitful collaborations and we will be happy to see in the future.

Concerning the limitations, one of the drawbacks of the systematic review is that the results come from one electronic library (Scopus). Extending the research to other databases might increase the number of the studies that meet the inclusion criteria. A second limitation is that this study presents only the state-of-the-art-literature. However, there might be relevant studies that were published before 2010. To the authors' knowledge, since it is the first multidisciplinary review an earlier period multidisciplinary approach will be able to present the evolution of the topic. A third limitation is the selection of the keywords and the searching methodology. Although the selection was on purpose generic, so that we can get as much as possible studies, probably a different keyword selection could return back slightly different results. Finally, the search of the key terms considered only the article titles because of our intention to get studies that were entirely devoted to the impacts of mobility. However, there might exist studies appropriate for inclusion that do not contain the combination of our selected keywords.

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