Infrastructure, innovation and industry as solutions for breaking inequality vicious cycles

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Infrastructure, innovation and industry as solutions for breaking inequality vicious cycles

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Abstract. Currently, poverty and inequality are crucial social issues around the world. They demand objective evaluations with the purpose of defining policies and prioritizing actions. Most of the times the most important problem lies on the fact that individuals under poverty circumstances or belonging to vulnerable collectives cannot escape these conditions by themselves and need external assistance or interventions. Another added difficulty is that both poverty and inequality can be studied from different angles and require a multidimensional approach whose definition is not straightforward. There exists a vicious cycle defined by a collection of determinants or events that lead to a phenomenon in which various disadvantages work circularly so that it is impossible for individuals or households to break the cycle.

In this context, setting the background in which these vicious cycles arise can be helpful in order to conduct in-depth studies as a first step to establishing possible solutions. Even though many researchers have proposed alternative schemes for the poverty's vicious circle, none has been introduced for inequality. In this contribution, a meaningful and integrated cycle is defined for inequality at two different levels: first of all, at an individual level; secondly, at a collective level in which a certain group is made vulnerable. This cycle includes similar parameter as those comprised in the poverty cycle such as income, access to education and access to healthcare. However, it additionally places emphasis on other aspects such as participation in politics and access to leadership positions.

Besides, a conceptual and analytical framework is built, whose objective is to describe ways in which infrastructure, innovation and industry can help interrupt the continuation of the cycle. This model integrates a collection of different measures that is to be potentially helpful for policy makers. Additionally, the frame accounts for not only the fight of current existing cycles, but also of future generations ones, hence considering sustainability dimensions.

1. Introduction

Inequality and poverty are growing problems around the world and many studies have been showing how the levels of these phenomena both within and between countries have increased in the last decades. Infrastructures have been recognised as having a fundamental role to play both in the generation and in the mitigation of these problems. Actually, there exists a growing amount of literature dealing with the relationship existing between infrastructure and growth and or human development. But infrastructure development not only has effects on human development and growth, but also on inequality. Despite the fact that some researchers have analysed the relationship between infrastructure, poverty and

inequality [1,2,3], this work has failed to address the multidimensional nature of these phenomena. Current analyses focus on inequality in economic terms and therefore fail to approach other dimensions such as education and health. An inherent issue to poverty is the fact that the conditions under which it occurs generate a collection of characteristics that make it difficult to escape them. In fact, many authors have dealt with the so-called vicious cycle of poverty and have proposed different versions for it [4,5,6]. Even though there exists a parallelism with the phenomenon of inequality, there is not yet literature describing how inequalities arise and propagate along time, making it difficult for individuals in vulnerable situations to escape from this vicious cycle. However, the understanding of these cycles is fundamental for the consideration of sustainability holistically.

Having said this, the objectives of this paper are two-fold. First of all, this paper aims to propose a structure for the vicious cycle of inequality with the objective of providing a better understanding of how this phenomenon arises and when and where are most useful the methodologies to tackle with it. This cycle exists both at an individual level and at a collective level and both are analysed. Secondly, we examine how these cycles can be interrupted through industry, innovation and infrastructure, which are the basis of the ninth Sustainable Development Goal.

The structure of the paper is as follows. Section 2 describes the methodology that has been followed for the analysis carried out in the development of the paper. Section 3 briefly introduces contributions dealing with the effects of infrastructure on problems such as human well-being, poverty and inequality. Then, section 4 describes the vicious cycles of poverty and of inequality. On the basis of these descriptions, section 5 discusses measures to be taken in order to break these cycles. Finally, section 6 concludes.

2. Methodology

The methodology that has been followed for this study is the one shown in Figure 1. First of all, a literature review was conducted with the objective of establishing the relationships that have been found between poverty and inequality with infrastructure, industry and innovation. Secondly, the results of the literature review were used to establish how the vicious cycle of poverty has been defined in other publications. This, together with the references dealing with inequality, was used at the same time as a source of information to describe a vicious cycle of inequality. On the basis of this cycle, several different key spots that may be helpful to break the cycles are identified and possible solutions are analysed.

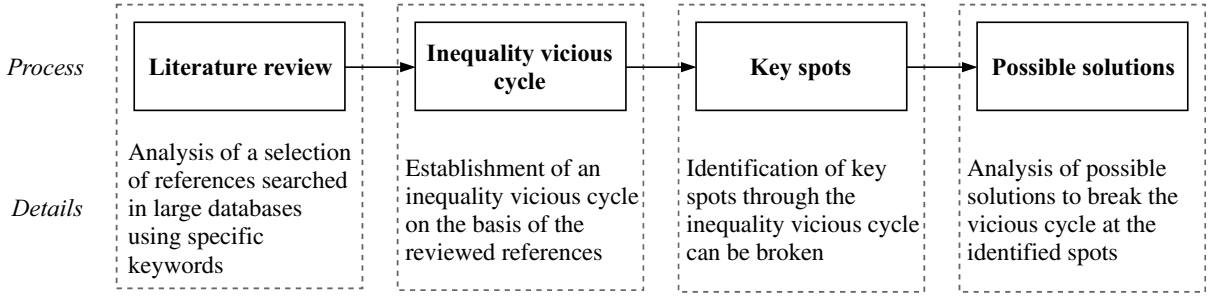

Figure 1. Diagram of the followed methodology

3. Literature review

There is general agreement on the fact that infrastructure development plays an important role both in developed and developing countries. However, authors tend to diverge with regard to the characteristics of this role. While some of them emphasise the benefits of infrastructures on economic growth [1], others point out at the fact that when the impact is positive in the sense that it leads indeed to an economic growth, it can have negative effects on the way assets are distributed among population, leading to an increase in interpersonal and interregional inequalities [2]. Besides, some analyses show that growth due to investment in infrastructure is not always positive and it depends on the kind of infrastructure, such as health, education, transport, energy and communication [7,8]. Other authors have analysed the

conditions under which investment reduces inequality [3]. Infrastructures can help in the reduction of inequality by improving mobility and geographic access and therefore enhancing people's access to job opportunities or children access to schools; also, it can serve to increase the value assets of those at the bottom of the distribution. Besides, communication infrastructure can be helpful for vulnerable groups to search, find and apply for productive opportunities to which they would otherwise not have access to. It must be emphasised at this point that although many authors have traditionally focused on inequality in monetary terms, inequality is a multidimensional problem and therefore it can occur in different areas apart from economy, such as health, education or participation. This means that even though in some situations infrastructure provisioning affects only one of these dimensions, they are correlated and other dimensions can indirectly be impacted.

Apart from the effects of infrastructure on inequality, several authors have analysed and empirically shown evidence on the relationship between innovation and disparities [9,10,11]. Nevertheless, there is disagreement on the kind of effect it has. [12], for example, show a positive correlation between innovation and social mobility; but [13] emphasise that even though innovation can lead to economic development, it does not ensure this growth to be totally inclusive.

It needs to be considered that there is a strong connection between built environment and poverty or inequality. This connection is related to sustainability. Even though a considerable amount of literature has analysed infrastructures' environmental sustainability, few writers have been able to draw on any systematic research into its social pillar [14,15,16,17]. However, according to some authors, it is only when a good or a service is socially sustainable that it is possible to start considering environmental sustainability [18].

Among the Sustainable Development Goals, the ninth provides a basis for understanding and dealing with issues concerning infrastructure, such as transportation networks, water provision and sanitation and energy infrastructure.

4. The vicious cycle of inequality

The circumstances under which children that live in poor families grow up substantially affect their personal and educational development. In this context, the access of the household to resources to cover their basic needs is minimal; therefore, these children lack access to enough food, to safe water and sanitation and to healthcare. As a result, the children may be malnourished and have health problems; this has as consequence a low productivity at school due to the lack of energy of the children or due to their incapability to attend school classes. They are disadvantaged in education and skills and have difficulties finding a job when older, which will make it complicated for him to escape the vicious cycle.

The cycle can also be analysed from the point of view of an adult. If he is living in a poor household he is probably disadvantaged in education and skills. At the same time, poverty will also restrict his access to food, safe water and healthcare, which leads to a higher probability of undergoing diseases or infections, as well as to a lack of energy. Altogether has as consequence less job opportunities or a low productivity at work, leading to unemployment or a low personal income. This can have effects on the personal stability and self-esteem of the individual and in some cases can result in increased child births; together with the high probability that there are sick adults at the household there is a greater number of dependants that need to survive with the household's low family income.

These cycles, the children and the adult ones, can be seen in Figure 2. They include the factors that authors have most commonly included in their analyses, even though small variations from the diagrams presented here can exist; these differences come generally from the point of view taken and from the depth of details in the description.

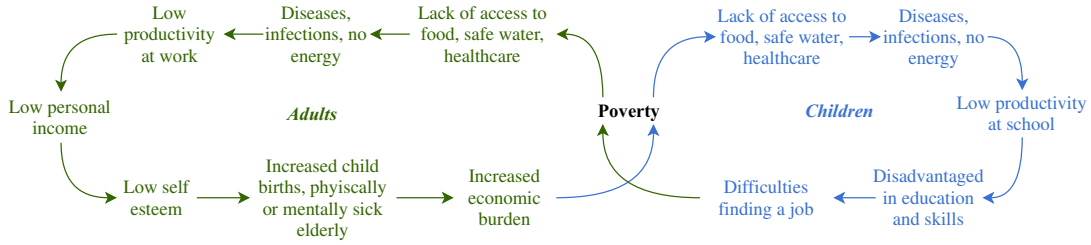

Figure 2 Poverty vicious cycles

Poverty vicious cycles have attracted greater attention and generally less attention has been paid to the vicious cycle occurring with inequality. While families living in vulnerable situations due to poverty it is possible to define the cycle for adults and for children, in the case of inequality there is a collective component that adds up to the household one. This is why in the case of inequality cycles, apart from differentiating between children and adults, we also describe the differences existing between inequality at individual and at collective levels. Figure 3 shows the inequality cycles at an individual or household level and at a collective level.

Firstly, at a household level, individuals (children or adults) that are in a vulnerable situation in terms of economy, health, education, etc. are disadvantaged in the access to basic needs (such as food, water and energy) and to basic services (such as healthcare and education). Therefore, they are more vulnerable to diseases and are prone to receiving worse education and achieving lower skills. As a consequence, there is more risk of being depleted and of getting sick; this, together with a worse level of education, leads to fewer work opportunities in comparison to other people who is more advantaged in these dimensions. This gives rise to an increase in unemployment or, in the case that they succeed in finding a job, to worse working conditions. In the end, they receive lower incomes and even though they live in worse conditions, they don't have enough resources to move to a better place, which restricts their social mobility.

Secondly, looking at inequality from a collective perspective, vulnerable groups are usually excluded or disadvantaged in social activities and environments and are often stereotyped; this affects their communicating strength within society, which has consequences on their influence and political power. In consequence, they are inadequately represented within society and their needs may be less visible among stakeholders or they may have less opportunities to impact on decisions made at different levels. Hence, their fundamental rights, such as basic needs, the right to no discrimination or the right to a decent life may be affected or even completely denied. In the end, the social mobility of the group is very limited and they continue to be in a vulnerable situation.

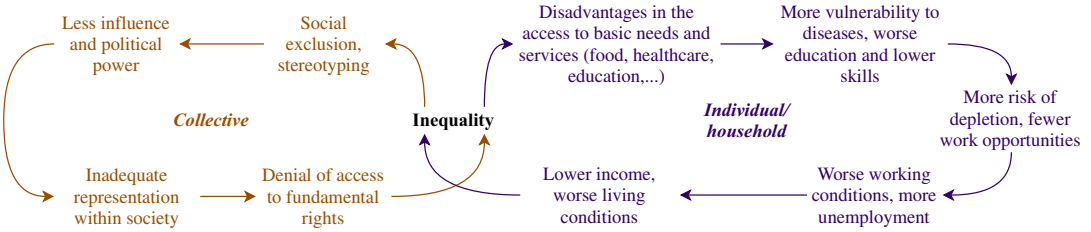

Figure 3 Inequality vicious cycles

5. Discussion: infrastructure, innovation and industry to tackle with inequality

In the previous sections we have introduced the state-of-art of the relationship between poverty and inequality and infrastructure and we have described the vicious cycles of poverty and proposed the cycles of inequality. The aim of this section is to analyse measures to tackle with the problem of inequality from three perspectives: infrastructure, innovation and industry.

On the basis of the conducted research, we have identified four domains through which the cycle can be broken at individual level, and one at collective level. For the former, there is: education, economic activity, health and quality of life, leisure; for the latter, there is participation in decision-making. We have described each domain in Table 1. In this table we also introduce the measures that we propose as key actions to break the vicious cycles. These measures are classified according to whether they correspond to infrastructure, innovation or industry.

First of all, as for education, the identified aspects relate to the lack of access to education or to the (low) levels of skills and education. [19] document the relationship between regional disparities and class sizes, number of teachers and counsellors, amount and quality of academic courses, amount of extracurricular activities, provision of books, materials, supplies and computers, quantity of libraries and special services. Education infrastructure such as schools plays an important role in education inequality. For example, [20] shows regional differences in education levels due to disparities existing in terms of infrastructures and of public education resources in Ghana. Therefore, it is necessary to invest in building and improving schools and other infrastructures with educational objectives and make them both sustainable and resilient (Aspect 1.1). Another aspect to account for is the access to education services. If there are no physical facilities or if there are barriers for children to attend school, some collectives might fail to achieve good levels of education. [21] emphasise how transport inequalities can have consequences on the capability of people to access certain activities such as education and training. If children belong to a vulnerable group, they either must rely on public transportation or they need to find their own means to get to school. Therefore, improving the public transportation system or the roads and paths through which children have to get to school is key to tackle this sort of inequalities; also, facilities need to be developed offered to children living in remote locations such as special transportation, platforms to connect families with the same problems and willing to share transportation or distance education (Aspects 1.2 and 1.3). Aspect 1.4 refers to the need for including social problems issues such as inequality in the education of children, and also of possible training of adults and of employers and employees in order to avoid the perpetuation of stereotypes and social stigmas. Finally, Aspect 1.5 proposes developing and producing new forms of school materials, to make them accessible and affordable for everybody, such as through ICTs.

Secondly, as for economic activity, [22] empirically show the relationship between income inequalities and geographical access to goods. [20] points at the fact that inequalities in access to employment can arise as an effect of transport inequalities. Therefore, ensuring that transportation can be accessed and afforded by all members of society is key, and this can be done by improving transportation infrastructure (Aspect 2.1). However, not all the problem comes from inequalities in physical access, but also from the lack of access to job opportunities. Some authors [23,24] argue that ICTs can have impacts on the quantity, quality and distribution employment opportunities as well as on income levels of vulnerable groups. However, this impact is not always positive in terms of inequality and quality of life; [24] present two different scenarios, a pessimistic and an optimistic one, and describe the effects of ICT on employment relations and employment protection, time and work autonomy and skills and careers. In Aspect 2.2 we emphasise the need of developing ICTs that are inclusive and accessible for all and that can have positive impacts on employment. Aspect 2.3 focuses on investments in science and technology research, which can generate new jobs and improve the existing ones. For instance, [17] empirically analyse the relationship between public investments in research and development with the change in poverty and inequality. Aspects 2.4 and 2.5 target the industry and claim first of all that in the working environment it is fundamental that all practices and standards are satisfied so that vulnerable people are not given a differential treatment; secondly, they advocate for the development and implementation of equity policies that can influence the industrial development positively, namely, inclusively and sustainably.

Table 1. Description of the main areas through which the vicious cycle of inequality can be broken and specific measures of action in the fields of infrastructures (INF), innovation (INN) and industry (IND)

	Key area	Description	Solution					References
				INF	INN	IND	Description	
			Individual level					
1	**Education**	Aspects related to disadvantages in the access to education, to the achievement of lower skills, to the unaffordability of education support materials and to raising awareness about the inequality problem	*1.1*	✓			Improve schools and buildings, make them more resilient.	[20,21]
			1.2	✓			Improve and make more affordable the physical access to schools (roads, bridges, etc.) from remote locations	
			1.3		✓		Develop methodologies and structures to facilitate access to education for children that are disabled or live in remote locations	
			1.4		✓	✓	Include inequality issues in education and training, raise awareness among society but also among companies	
			1.5		✓	✓	Develop and produce new forms of school materials, to make them accessible and affordable for everybody	
2	**Economic activity**	Aspects related to inequalities in the access to job opportunities, to mobility-related access problems to work positions, to the inclusivity and sustainability of employment	*2.1*	✓			Improve physical access from vulnerable locations to locations with high economic activities	[20,22,23, 24,25]
			2.2		✓		Facilitate access to ICT to vulnerable groups, which can help searching and finding jobs	
			2.3		✓		Invest in science and technology research, which can generate new businesses, create and improve jobs	
			2.4			✓	Ensure that all practices and standards related to labour are satisfied	
			2.5			✓	Develop and implement policies for more inclusive and sustainable industrial development	
3	**Health and quality of life**	Aspects related to access to healthcare services, to environmental control	*3.1*	✓			Improve physical access to healthcare centers	[26,27]
			3.2	✓			Healthcare infrastructure	
			3.3	✓			Environmental infrastructure	
			3.4		✓		Develop more affordable, accessible and sustainable: (1) methodologies to remove toxic substances from drinking water and food, (2) energy sources	
			3.5			✓	Implement and promote the removal of toxic substances from drinking water and food	
4	**Leisure**	Aspects related to activities performed during free time	*4.1*	✓			Improve urban areas and build healthy spaces	
			Collective level					
5	**Political power and participation in decision-making**	Aspects related to the relationships between society and vulnerable groups and to the inclusion of these groups in decision processes	*5.1*	✓			Improve built environment where vulnerable groups get together	[31]
			5.2	✓			Facilitate access to buildings or develop projects of buildings where vulnerable groups can meet, organise themselves, discuss, etc.	
			5.3		✓		Develop accessible forms through which disadvantaged groups can participate in decision-making processes, such as ICTs	
			5.4		✓	✓	Improve inequality-related policies and raise awareness	

Fourthly, one aspect that has been less analysed is related to how individuals spend their free time. As it was observed in the vicious cycle, social problems such as inequality can psychologically affect individuals. Actually, many authors have described and empirically examined evidence on the relationship existing between leisure and physical, social, emotional and cognitive health [28,29,31]. Therefore, promoting and engaging people in mentally and physically healthy activities can strengthen their self-confidence.

Finally, it is necessary to work towards strengthening the political power of disadvantaged groups and towards increasing their access to participation in decision-making processes that may affect them. As pointed out in [31], factors making groups more vulnerable are their living environment (such as their neighbourhood) and the type of social relationships established between them. Therefore, a first way to tackle with this problem is to fight against the effect that a degraded or negative environment has on the reinforcement of inequality (Aspect 5.1) by improving urban areas. Also, it is necessary to facilitate and reinforce the relationships between people belonging to vulnerable groups and between pressure groups and vulnerable people so that they can fight against their exclusion or stereotypes collectively (Aspect 5.2). Aspect 5.3 points out at the need for making it easier for disadvantaged groups to taking part in decision-making processes by developing new forms of participation. Finally, Aspect 5.4 emphasises the fact that one way to break the cycle is through awareness campaigns and development of inclusive social policies.

6. Conclusions

This paper has analysed the relationship between inequality and infrastructures, innovation and industry and has described the main factors that boost the perpetuation of inequality in time, generating a vicious cycle of inequality. The considerations taken in the presented cycle of inequality are: the level at which it occurs (individual/household or collective) and if it is representative of children or of adult.

The analysis carried out has been used to identify at which points the inequality vicious cycle can be broken. The four areas that are fundamental at individual level are: education, economic activities, health and quality of life and leisure. As for the collective level, it is important to take measures on political power and on participation in decision-making processes.

For each of the identified areas specific measures have been proposed, each one belonging to at least one of the categories infrastructures, innovation and industry. The number of measures that have been described are five for education, five for economic activity, five for health and quality of life, one for leisure and four for political power and participation in decision-making.

The following key characteristics have been established for each of the three areas of action:

- Infrastructure: construction of inclusive basic facilities (aimed at everyone), mobility logistics, physical accessibility, improvement of the living physical environment.
- Innovation: expansion of technologies, development of new skills.
- Industry: production of goods, production of services, satisfaction of ethical standards, promotion of good practices.

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References

[1] Calderón C and Servén L 2004 *The Effects of Infrastructure Development on Growth and Income Distribution* (The World Bank)

[2] Bajar S and Rajeev M 2016 The Impact of Infrastructure Provisioning on Inequality : Evidence from India *J. Comp. Asian Dev.* **15** 122–55

[3] Klenert D, Mattauch L, Edenhofer O and Lessmann K 2016 Infrastructure and inequality: insights from incorporating key economic facts about household heterogeneity *Macroeconomic dynamics*

[4] Vorster H H 2010 The link between poverty and malnutrition: A South African perspective *Heal. SA Gesondheid* **15** 1–6
[5] Karekezi S, McDade S, Boardman B, Kimani J and Lustig N 2012 Energy, Poverty, and Development *Global Energy Assessment: Toward a Sustainable Future* ed Global Energy Assessment Writing Team (Cambridge: Cambridge University Press) pp 151–90
[6] Bain L E, Awah P K, Geraldine N, Kindong N P, Sigal Y, Bernard N and Tanjeko A T 2013 Malnutrition in Sub - Saharan Africa: Burden, causes and prospects *Pan Afr. Med. J.* **15** 1–9
[7] More I and Aye G C 2017 Effect of Social Infrastructure Investment on Economic Growth and Inequality in South Africa: A SEM Approach *Int. J. Econ. Bus. Res.* **13.2** 95–109.
[8] Simon N S and Natarajan P 2017 Nonlinearity between infrastructure inequality and growth: Evidence from India *Rev. Mark. Integr.* **9** 66–82
[9] Falkinger J 1994 An Engelian model of growth and innovation with hierarchic consumer demand and unequal incomes *Ric. Econ.* **48** 123–39
[10] Zwemüller J 2000 Schumpeterian Entrepreneurs Meet Engel ' s Law : The Impact of Inequality on Innovation- Driven Growth *J. Econ. Growth* **5** 185–206
[11] Pieroni L and Pompei F 2008 Evaluating innovation and labour market relationships: the case of Italy *Cambridge J. Econ.* **32** 325–47
[12] Aghion P, Akcigit U, Bergeaud A, Blundell R and Hémous D 2015 Innovation and Top Income Inequality *Natl. Bur. Econ. Res. Work. Pap. Ser.* **No. 21247**
[13] De Palo C and Raab R 2018 *Innovation and inequality in the EU: for better or for worse?*
[14] Sahely H R, Kennedy C A and Adams B J 2005 Developing sustainability criteria for urban infrastructure systems *Can. J. Civ. Eng.* **32** 72–85
[15] Ugwu O O and Haupt T C 2007 Key performance indicators and assessment methods for infrastructure sustainability-a South African construction industry perspective *Build. Environ.* **42** 665–80
[16] Newell J P, Seymour M, Yee T, Renteria J, Longcore T, Wolch J R and Shishkovsky A 2013 Green Alley Programs: Planning for a sustainable urban infrastructure? *Cities* **31** 144–55
[17] Bocchini P, Frangopol D M, Ummenhofer T and Zinke T 2013 Resilience and Sustainability of Civil Infrastructure: Toward a Unified Approach *J. Infrastruct. Syst.* **20** 04014004
[18] Vallance S, Perkins H C and Dixon J E 2011 What is social sustainability? A clarification of concepts *Geoforum* **42** 342–8
[19] Darling-Hammond L 2007 Race, inequality and educational accountability: the irony of 'No Child Left Behind' AU *Race Ethn. Educ.* **10** 245–60
[20] Senadza B 2012 Education inequality in Ghana: gender and spatial dimensions *J. Econ. Stud.* **39** 724–39
[21] Lucas K 2004 *Running on empty* (Bristol University Press)
[22] Redding S and Venables A J 2004 Economic geography and international inequality *J. Int. Econ.* **62** 53–82
[23] Arun S, Heeks R and Morgan S 2010 ICT initiatives, women and work in developing countries: reinforcing or changing gender inequalities in South India?
[24] Rubery J and Grimshaw D 2001 ICTs and employment: The problem of job quality *Int. Labour Rev.* **140** 165–92
[25] Fan S, Zhang L and Zhang X 2002 Growth, Inequality, and Poverty in Rural China: The Role of Public Investments. Research Report 125 *IFPRI, Washington, DC* 82
[26] Stuckler D, Basu S and McKee M 2011 Health care capacity and allocations among South

Africa's provinces: Infrastructure-inequality traps after the end of apartheid *Am. J. Public Health* **101** 165–72
[27] Ele-Ojo Ataguba J, Day C and McIntyre D 2015 Explaining the role of the social determinants of health on health inequality in South Africa *Glob. Health Action* **8** 28865
[28] Cassidy T 1996 All work and no play: A focus on leisure time as a means for promoting health *Couns. Psychol. Q.* **9** 77–90
[29] Caldwell L L 2005 Leisure and health: why is leisure therapeutic? AU - *Br. J. Guid. Counc.* **33** 7–26
[30] Mannell R C 2007 Leisure, Health and Well-Being *World Leis. J.* **49** 114–28
[31] Mechanic D and Tanner J 2007 Vulnerable People, Groups, And Populations: Societal View *Health Aff.* **26** 1220–30