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The implications of megatrends in information and communication technology and transportation for changes in global physical activity

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Abstract

Physical inactivity accounts for more than 3 million deaths per year, most from non-communicable diseases in low-income and middle-income countries. We used reviews of physical activity interventions and a simulation model to examine how megatrends in information and communication technology and transportation directly and indirectly affect levels of physical activity across countries of low, middle, and high income. The model suggested that the direct and potentiating effects of information and communication technology, especially mobile phones, are nearly equal in magnitude to the mean effects of planned physical activity interventions. The greatest potential to increase population physical activity might thus be in creation of synergistic policies in sectors outside health including communication and transportation. However, there remains a glaring mismatch between where studies on physical activity interventions are undertaken and where the potential lies in low-income and middle-income countries for population-level effects that will truly affect global health.

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Contributors
MP designed the study and other authors provided critical input. OLS and FM did the systematic search and modelling procedures, and developed the tables and figures with input from the other authors. All authors drafted sections of the report and provided critical review of the draft.

Conflicts of Interest
We declare that we have no conflicts of interest.

Introduction

Non-communicable diseases account for 60% of all deaths globally, and 80% of these deaths occur in low-income and middle-income countries.[1] An epidemiological transition from a burden of disease dominated by communicable diseases to one dominated by non-communicable diseases[2] is now occurring in countries with low and middle incomes as it has previously in those with high incomes.[3] Physical inactivity is a major risk factor for non-communicable diseases, accounting for an estimated 3·2 million deaths per year.[4] Most of these deaths, as well as the huge burden of morbidity and disability attributable to physical inactivity, take place in countries with low and middle incomes. Public health attention to physical inactivity has evolved rapidly in the past decade, as shown by the 2004 WHO global strategy on diet, physical activity, and health,[5] the 2010 WHO global recommendations on physical activity for health,[6] and the central role of physical activity in the 2009 WHO action plan for the global strategy for the prevention and control of non-communicable diseases[7] and the UN General Assembly summit on non-communicable diseases.[8]

A major goal for public health is to identify evidence-based interventions to promote physical activity in populations. To do so, several types of evidence are needed.[9–11] Type 1 evidence defines the causes of disease due to physical inactivity and the magnitude, severity, and preventability of inactivity. Type 2 evidence describes the effectiveness of specific interventions that address physical inactivity. Type 2 evidence (summarised in the Cochrane Library, Community Guide reviews, or UK National Institute for Health and Clinical Excellence [NICE] guidance) identifies effective interventions for promotion of physical activity.[12,13] Type 3 evidence shows in what contexts interventions are implemented and how they can be adapted from one population to another (eg, from a high-income country to those with low and middle incomes).[9,11] Most intervention studies have not been done in countries with low and middle incomes and have not addressed the question of how effective interventions can be adapted from one country to another.[14] The scarcity of type 3 evidence suggests a need for increased attention on the external validity of studies (the extent to which findings can be applied to other populations, settings, and times)[15,16] to complement the emphasis so far on the internal validity of well controlled effectiveness trials.

During consideration of which interventions are appropriate and effective, the usual evidence hierarchies might not apply. The randomised controlled trial is typically regarded as the most robust study design to test hypotheses about the effects of interventions.[17] As such, randomised controlled trials are often more likely to be funded, published, and included in systematic reviews. However, well designed observational studies (including studies of so-called natural experiments)[18] can also be powerful aids to estimation of risk, understanding of disease, and evaluation of interventions,[19] particularly in the policy arena, in which random assignment of exposure might be politically or practically infeasible. In these situations, alternative research designs[20] are often best to address policy-relevant questions.

The challenges and opportunities in prevention of non-communicable diseases indicate several important megatrends—defined as major forces in societal development that are likely to shape people's lives during the next 10–15 years. Many of the actions that affect population levels of physical activity might occur outside the health sector and potentially be shaped by mega trends. Factors such as environmental justice and social equity, economic and technological development, trans port, urbanisation, pedestrian-oriented urban develop ment, and global communication could have much greater effect on physical activity than do strategies derived from a traditional medical or public health perspective. Environmental justice refers to the need to improve environmental conditions for populations challenged by poverty, poor education, and scarcity of resources.[21] These conditions are closely related to social inequity, which implies an unfair distribution of social, cultural, and environmental resources between advan taged and disadvantaged groups.[22,23] Environmental conditions include the built environment, public space, and other structural factors that affect health behaviours such as physical activity.[24–26] Addressing of inequalities in access to facilities, safe public spaces, and other supports for active lifestyles is often the first step in promotion of physical activity. The growth of information and com munication technologies such as the worldwide web and mobile phones provides new opportunities for delivery of physical activity interventions, but also poses challenges for upholding of principles of social equity across the digital divide. Similarly, the potential physical activity benefits of new public transport and pedestrian and bicycle route networks might be threatened by increasing ownership and use of private cars, particularly in countries with low and middle incomes.

We aimed to improve understanding of the effectiveness and potential effect of interventions to address the global burden of physical inactivity. We had five objectives: (1) to assess the potential effect of megatrends in information and communication technologies and transport on physical activity; (2) to use the findings of a targeted review of physical activity interventions to guide development of a simulation model; (3) to model the changes in population physical activity that are potentially attributable to and affected by these mega-trends within the clinical, public health, and intersectoral domains; (4) to illustrate key issues through case studies; and (5) to provide policy-related recommendations related to the findings of the analyses.

Megatrends in information and communication technologies and transport

Background

Physical activity promotion has developed in recent decades from a focus on individual behaviour change to the wider societal and environmental determinants of health-rel ated behav iour.[27,28] Two major themes of contem porary societal change are the development of information and com munication technologies and the growth in use of motor vehicles. Both these megatrends could have a bearing on the promotion or maintenance of physical activity in populations, especially because differential access to these technologies, across and within countries, could affect existing health inequalities. They should therefore be considered through the perspective of social equity in assessments of their potential to reach and influence individuals, particularly those in greatest need of low-cost interventions.[29]

Information and communication technologies

Information and communication technologies are expanding very rapidly worldwide. Access to the internet, for example, increased enormously from 1997 to 2009 (from 0·01% to 4·3% of the population in low-income countries; from 0·21% to 23·8% in middle-income countries; and from 11·2% to 51·9% in high-income countries). Mobile phone access increased similarly from 1997 to 2009 (from 0·05% to 28·9% in low-income countries; from 1% to 71% in middle-income countries; and from 17·9% to 96·3% in high-income countries). These large increases present a challenge for identification and testing of effective technologies to change health behaviours. Physical activity is one of many health behaviours that have the potential to change substantially as a result of increasing availability of information and communication technologies and of technology-based interventions.

The internet is identified as an important source of health information by more than half its users[30] and could, therefore, be a useful medium for physical activity interventions. Most research into use of the internet for physical activity health promotion has been done in the USA[31–38] (with additional studies in Canada,[39] Australia,[40,41] Switzerland,[42] and the Netherlands[43]) and mainly on healthy but overweight and fairly sedentary white adults, especially women.[38,40,43–46] Overall, web-based interventions show small positive effects. How ever, on the basis of our review, few internet-based physical activity trials have used programme features specifically matched to theoretical constructs known to result in changes in physical activity behaviour and likely to increase effectiveness.

Around 95% of countries have mobile telephone networks, about 70% of people worldwide use mobile phones,[47] and most countries have more mobile phone subscribers than fixed landlines.[48] Much of the recent proliferation of mobile phone use has occurred in low-income and middle-income countries.[47,48] Mobile phones have attracted less attention than the internet for research on physical activity promotion.[49] Although mobile phone calls can be taken on the go, delivery of interventions over the telephone still needs scheduling, staffing, and other resources. However, the more direct, personal interaction from phone calls creates a greater sense of personal and social support than do traditional face-to-face interventions, which is associated with improved health outcomes.[50]

Mobile phone short-message service (SMS) presents a promising application for delivery of interventions because of its widespread use in less affluent and less healthy populations. SMS is pervasive across cultures, socioeconomic backgrounds, and country economic development levels, with an estimated 4 billion users worldwide.[51] This service allows instantaneous delivery of short messages (maximum 160 characters) that can be accessed at a time that suits recipients, including when they are in situations or environments that are conducive to physical activity or involve making choices between active and sedentary options. SMS can also be more cost-effective than telephone calls and allows for two-way communication, in which participants can send information to elicit feedback and interact asynchronously and flexibly.[52]

The gap between people with effective access to digital and information technology and those without has been referred to as the digital divide.[53] The idea was originally popularised with respect to the disparity in internet access between rural and urban areas of the USA,[54,55] but it also refers to wider inequalities in access by sex, income, race, and location.[55] People who are overweight, of low socioeconomic position, and who might, there fore, stand to gain the most from an intervention to promote physical activity might be less likely to have access to internet technology. The global digital divide refers to the uneven development of the internet throughout the world and the associated disparities in access to information, education, and business oppor tunities between wealthy countries and those with low and middle incomes.[56–59] Interestingly, however, poor populations globally have been early adopters of mobile phones, emphasising that costs are not a substantial barrier to mobile phone service.[60] The highest mobile phone use in the USA occurs in adolescents, young adults, socioeconomically disadvantaged populations, and people who rent their homes or frequently change addresses.[61] Whether considered within a country or globally, the digital divide that has been noted for internet access does not seem to be present for mobile phones (figure 1). Therefore, mobile phones have great potential to reach populations that previously had restricted access to interventions or health-care information.

Transport

The potential to promote physical activity through transport exemplifies the importance of intersectoral approaches to policy and assessment;[63–65] walking and cycling are forms of recreational activity as well as modes of daily transport that can replace trips previously made by motor vehicle. Reduction of journeys made in vehicles should be a complementary policy goal to that of promotion of physical activity because reduction of sedentary time, such as that spent in cars, might also be important for chronic disease prevention, and use of motor vehicles is associated with various wider population health consequences including injuries, noise, local air pollution, and carbon emissions.[66] A modelling study[67] based on London and Delhi showed that although reduction of carbon emissions through technical modification of the vehicle fleet would have some health benefits, much greater population health benefits would be realised by active travel substitution, in which a large proportion of urban trips are shifted to walking and cycling, even after any increase in injuries was taken into account.[68] Investigators applying alternative model assumptions to different datasets have reached much the same conclusions.[67,69]

The growth in ownership and use of private cars—particularly in high-income countries such as the UK, where annual kilometres travelled by car or van have increased more than ten times since the 1950s[70] (figure 1)—has made it possible for people to live, work, shop, and pursue leisure activities in widely dispersed locations. In such contexts, car ownership might be important to enable access to opportunities and amenities, and is associated with reduced morbidity and mortality even after adjustment for other markers of socioeconomic status.[71–73] However, Illich[74] argued in the 1970s that the mobile car-based society had created universal enslavement, and Adams' more recent notion of hypermobility encapsulates the idea that ever-increasing mobility imposes unacceptable social costs and that it is, therefore, possible for a society to have too much of a good thing.[75] This opinion is especially important since in countries such as the UK, car ownership,[76] carbon emissions from private motor vehicles,[77] and child pedestrian mortality[78] are all strongly socially patterned: people who benefit most from the hypermobile society are usually not those who bear the brunt of the adverse effects. These costs of widespread motorisation are also not limited to high-income countries, as shown by the increase in body-mass index associated with a transition from cycling to car use in adults in China,[79] where the total motor vehicle fleet increased ten times between 1990 and 2005.[80]

By contrast with private motor vehicles, improvement of public transport such as bus or rail services might allow participation in physical activity, particularly in the form of walking at either end of the journey. Evidence from cross-sectional studies in the USA, Australia, Europe, and Colombia suggests that people who use, or have access to, public transport are more likely to walk and tend to be more physically active than are those who do not.[81–85] Promotion of physical activity is unlikely to be the primary concern of transit systems, but if the needs of pedestrians and cyclists are properly addressed in the design of vehicles, stations, and their surroundings, schemes such as the TransMilenio bus rapid transit (BRT) in Bogotá could help to increase the use of active travel while providing high-quality public transport at a lower cost than traditional rail services (see case study on urban transformation in Bogotá, panel 1).[90] Evidence from robust intervention studies is scarce at present, but favourable trends in travel patterns have been reported in many cities that have introduced integrated urban transport policies.[91] Further implemen tation and assess ment of these interventions are important because controlled studies of interventions to promote cycling suggest that their effects are small.[92] Interventions to promote walking have a stronger evidence base, although their effectiveness to increase physical activity might depend on targeting of specific groups or settings.[93] The evidence shows an evaluative bias whereby interventions applied to whole populations have tended to be assessed by less rigorous methods than those applied to small groups of motivated volunteers.[94]

Megatrends related to information and com munication technologies and transport might have sub stantial potential effects on physical activity promotion, even though so far fairly few studies have focused on these areas.

Physical activity intervention reviews

We did a systematic search to identify the latest reviews of published work about interventions to increase physical activity to provide input for a simulation model of physical activity interventions and megatrends. We used several electronic databases, websites, and published sources for our search: Clinical Evidence, Cochrane Library, Centre for Reviews and Dissemination (DARE admin database, HTA, NCCHTA), Embase, National Guidelines Clearinghouse, Medline, PubMed, NICE, PsycINFO, SIGLE, Sociological Abstracts, and TRIP. We searched the databases for systematic reviews or meta-analyses related to inter ventions and physical activity in human beings, published from Jan 1, 2001, to July 31, 2011, and PubMed from Jan 1, 2000, to Dec 20, 2011 (for methods see appendix pp 9–10). Reviews were classified according to setting and type of intervention (clinical, community, schools, workplace, or other) and, for technology-based interventions, whether they were delivered by mobile phone or over the internet. When a systematic review or meta-analysis did not provide pooled effect estimates, but did provide standardised mean differences, we estimated pooled mean effect sizes using a random effects model or reported a range of effect estimates. The standardised mean effectcorresponds to the effect size of an intervention for promotion of physical activity standardised to a uniform scale. To obtain the stand ardised mean effect, we used the standardised mean differences method. This method expresses the size of the treatment effect in each trial relative to the variability in that trial (appendix p 2).

We analysed 100 reviews of physical activity interventions (appendix p 9). Five systematic reviews were reviews-of-reviews, 19 were meta-analyses, and 76 were narrative reviews that did not provide quantitative effect estimates results from pooled effects or meta-regressions. 18 reviews covered interventions in clinical settings, 14 described community settings, five covered school settings, five described workplace settings, and the remainder consisted of several settings or reported not having a setting restriction for the search and synthesis. 60 reviews included studies done in high-income countries, whereas only eight included studies done in low-income and middle-income countries; 32 reviews did not include country-specific information. Seven reviews examined internet-based or web-based interventions; three dealt with mobile phone interventions; and four addressed interventions in the transportation sector. 50 reviews were of studies of adults; 19 of children and adolescents; 11 of adults and children; three of older adults; 13 of any age group; and four did not specify the age group.

Taken as a whole, the evidence in our review showed consistent, significant effects of the interventions on physical activity behaviours. Full results of the review of physical interventions are reported elsewhere in *The Lancet*.[95] In view of the large reach of some of these interventions (eg, mobile phones), the prevented fraction is potentially large, and thus we developed the model that follows. We chose the results from the systematic reviews (appendix p 6) as inputs for the model because they included the megatrends of interest in this study.

Simulation model for megatrends and physical activity interventions

We designed scenarios to assess the potential effect of interventions taking into consideration the effects of megatrends by country income. The megatrends used in the models were internet access, mobile phone access, and car ownership, including the effect of fuel price on car ownership. The model for information and communication technology interventions included those delivered directly via these technologies and the facilitating effects of the technologies on other physical activity interventions (appendix pp 4–5). The model for car ownership included the relation between active travel time (as a proxy for physical activity) and private car ownership (appendix pp 7–8). Megatrends and country classification by income are based on the 2011 world development indicators from the World Bank database.[96] The World Bank's main criterion for classifying econ omies is gross national income per head (appendix p 2). We selected the effect estimates for physical activity interventions from the most recent systematic reviews, and based the effect estimate for car ownership on the one available study, a cross-sectional study from the UK.[75]

Our model showed that the potential effect of web-based interventions on physical activity, at the population level, is positive and varies by country income. The estimates by country income showed a dose-response relation (figure 2), showing that the potential effect increases as country income increases (0·65 min per week for countries with low income; 1·71 min per week for lower-middle income; 4·78 min per week for upper-middle income; and 8·88 min per week for high-income). Because the total population of middle-income countries is much greater than that of high-income countries, the weighted potential effect size (appendix p 4; the potential population reached weighted by the potential effect size) for middle-income countries (3·44) is double that of high-income countries (1·46) for the internet access contribution to the expected population min of physical activity per week (table 1).

As for our findings for web-based interventions, we identified a positive potential effect of mobile phone inter ventions on physical activity at the population level. The estimates by country income, however, showed a dose-response relation different from that of internet-based interventions (figure 2); specifically, increasing linearly from low income to upper-middle income (4·37 min per week for countries with low income; 8·22 min per week for lower-middle income; 13·52 min per week for upper-middle income; and 14·03 min per week for high-income countries) and then reaching a plateau. As with internet-based interventions, the greater proportion of the global population in middle-income countries is important for projection of the population-weighted potential effect sizes (appendix p 4) for mobile-phone-based interventions. The population-weighted contribution to the expected min of physical activity in middle-income countries (7·91) exceeds that of high-income countries (2·27; table 1).

Whereas our findings for mobile-phone-based and web-based interventions show a positive potential effect on physical activity at the population level, we identified a negative potential effect of car ownership on population-level active travel. The estimates by country income showed a dose-response relation, indicating a larger negative effect as country income increased (−0·12 min per day for low income; −0·48 min per day for lower-middle income; −0·80 min per day for upper-middle income; and −3·11 min per day for high income; table 2). In view of the population distribution across countries by income, we did not expect to find a difference in the negative contribution to the expected min of active travel per day in middle-income countries versus high-income countries. When we adjusted the estimates by fuel pricing increment, the negative effect decreased slightly. The weighted decrement was 0 for low-income countries and 0·01 for middle-income and high-income countries. The SD for each potential effect estimate was high, possibly relating to the uncertainty of the results from use of one study (table 2). For the sensitivity analysis, we estimated the error of the Monte Carlo approximation accounting for the point estimate and its 95% CI (−6 min, 95% CI −12·04 to −0·32; table 2).

Discussion and conclusions

Type 1 evidence from 100 reviews of community-based and clinic-based physical activity interventions, including rigorous evidence-based reviews, consistently showed small improvements of physical activity in the short and medium terms. Effect sizes were small for individuals (pooled overall effect size in healthy adults of 14·7 min of physical activity per week[97]), but large enough to promise real population-level benefits if these interventions can be applied on a large scale. Geoffrey Rose's classic observation that small mean changes at the individual level often lead to substantially greater effects at the population level seems likely to apply for physical activity.[98] A glaring mismatch exists, however, between where the studies on physical activity interventions have been done and where the potential lies for population-level effects that can truly affect global health (figure 3), suggesting a scarcity of type 3 (contextual) evidence. Of the 95 primary reviews of interventions that we identified, only eight included studies done in middle-income and low-income countries. This disparity would be of little importance if country and cultural context did not matter in the selection and effectiveness of interventions. The results of an evidence-based review of physical activity interventions in Latin America, however, suggest that there are major differences between the types of physical activity interventions used in North and South America.[86]

Countries with low and middle incomes account for 84% of the global population, 80% of mortality from noncommunicable diseases, and—as shown in the simulation model—most of the potential increase in population physical activity. The potential effect of information and communication technologies and transport megatrends is also more important in countries with low and middle incomes than in those with high incomes, even though penetration of the technologies is greatest in high-income countries. An especially interesting contrast was noted between the distributions and trends for internet access and mobile phone ownership by country income. Internet access is much higher in high-income countries, whereas access to mobile phone and SMS technology is already almost equal in countries with upper-middle and high incomes; by 2020, this pattern is also likely to be true for countries with lower-middle incomes.

This type of contextual evidence has important ramifications for delivery of public health interventions to address physical inactivity. The direct and potentiating effects of information and communication technologies are impressive compared with the pooled overall effect sizes of planned physical activity interventions. For example, our model predicts an effect of web technology on physical activity interventions in high-income coun tries of 9 min per week, and effect sizes of 14 min per week for mobile phone technology in countries with upper-middle and high incomes. In other words, the potentiating effects of these widespread technologies are roughly the same size as the mean effect size of targeted physical activity interventions. During the next decade, the relative reach and importance of SMS technology in low-income and middle-income countries will further increase. Just as for research in these countries, however, little research exists on mobile-phone-based and SMS-based physical activity interventions. Only three of the 95 primary reviews that we identified focused on mobile phones, of which none included studies done in low-income and middle-income countries. We therefore have little knowledge of the effectiveness of the types of interventions that might be potentiated by these influential global megatrends.

Social equity is an important modifier of the potential effectiveness of physical activity interventions. Increased access to information and communication technologies and motor vehicles has been associated with sedentary lifestyles, as well as with wealth, within and between countries. The digital divide, however, might not apply to all technologies. The case study of an SMS-based physical activity intervention (panel 2) shows that this intervention strategy can be effective in a low-income population at high risk of inactivity. The results of our simulation model show that because access to SMS differs little between middle-income and high-income countries, the modelled effect of SMS on physical activity is actually increased in middle-income countries, which account for 71% of the global population; this conclusion suggests that mobile phones might be a less inequitable way of delivering interventions to promote physical activity than would be the internet in countries of all incomes.

Similarly, within the transport sector, there might be positive effects from trends in development and technology in addition to the well documented negative health effects of motor vehicle use. The case study of congestion charging in London, UK, presented in the appendix p 12, is a good example of a transport-sector policy already used in high-income countries and dependent on automatic number plate recognition, mobile communications, and related tech nologies for its successful operation, which has the potential to increase the use of physically active modes of transport (walking and cycling). Of even greater relevance is the case of Bogotá, Colombia, where a series of urban policies, infrastructure changes, and programmes are associated with increased physical activity. The best studied programme in Bogotá, the Ciclovía, attracts about a million users every week, most from low and middle socioeconomic strata. The case studies that we present suggest that not all trends in transport, development, and technology will inevitably have undesirable effects on physical activity, and that some types of interventions might actually narrow gaps in physical activity and health associated with social inequity.

Our model has several limitations. As noted, very few studies of physical activity interventions have been done in low-income and middle-income countries. Effect size estimates are, therefore, disproportionately affected by studies from high-income countries and might not accurately reflect interventions applied worldwide. Although megatrends for information and communication technologies and car ownership are clear, few data are available for the association between these factors and physical activity. Modelling of the complex bidirectional associations that potentially exist between information and communication technologies, car owner ship and use, and overall transport choices is especially difficult. For example, car ownership might be associated with inactivity and obesity, but also with improved overall health status. Increased access to infor mation and communication technologies can increase sedentary time, but might also allow delivery of physical activity interventions. We could not include the potential positive effect of urban planning and transport inter ventions, such as BRT and the Ciclovía, in the model because effect sizes on physical activity for these strategies have not yet been reported.

There are also limitations inherent in the structure of the model that we developed. We fitted the potential effects of physical activity interventions as random distributed variables, independent of megatrend exposure. We assumed independence between the intervention effect estimates and megatrend exposure, but actual global data for the relation between exposure to megatrends and interventions are not available. Future studies might consider a Bayesian approach, including the conditional probability of exposure to an intervention given megatrend exposure. For example, studies of internet-based inter ventions could take into account varying exposure to the megatrend by tracking of webpage traffic. For car owner ship, studies need to assess the potential for activity substitution (eg, use of car versus walking, cycling, or use of another type of motor vehicle) with specific physical activity inter ventions. Unlike the models for the internet and mobile phone megatrends, the model for car ownership depended on one estimate of the exposure-outcome relation between car ownership and active travel time from a cross-sectional observational study in the UK.[75]

Even with these limitations, the results of our review of physical activity interventions and the simulation model incorporating these reviews and megatrends have important implications for research and policy. A much more global perspective is clearly needed for both physical activity research and practice. Physical activity interventions and policies are unlikely to be optimised when more than 90% of the evidence and experience comes from high-income countries, while 84% of the world lives in the very different context of low-income and middle-income countries. This issue also suggests a major need to develop research capacity for physical activity within countries with low and middle incomes to build a contextually appropriate base of type 3 evidence.

Megatrends and policies in sectors beyond health seem to have major potential effects on population-level physical activity. To improve understanding of these complex effects, multisectoral research teams incorporating behavioural, economic, and social sciences using a combination of qualitative and quantitative methods, including modelling and policy analysis, will be needed. The challenge of focusing research in countries with low and middle incomes, at the same time that the overall complexity of methods and research teams is mounting, could be partly addressed by an increased emphasis on international collaboration in research and training.

Although technology-based physical activity interventions seem promising, they certainly need additional insight and improvement. Global access to these technologies, as well as the effects that they might have on activity and inactivity, need to be considered. Our model suggests that policies focused on enhanced access to mobile phones and delivery of interventions by this medium could be especially important. New technolo gies, such as smartphones, interactive voice response, and interactive video games, are increasingly prevalent in high-income countries, but are more expensive than traditional mobile phones. These technologies might become important mediums for promotion of physical activity globally, if prices drop sufficiently for them to become as ubiquitous as standard mobile phones are today.

Policy changes in transportation and planning will also be important. Intersectoral approaches with the potential to promote physical activity as a cobenefit already exist, including carbon pricing, integrated transit systems, traffic restriction, and increasing green space and bike-pedestrian networks. Enhancement of these strategies, especially in the context of countries with low and middle incomes, and consideration of social justice and equity seem to be logical steps towards improved promotion of global physical activity. As important as it might be to improve placement of physical activity within health-care systems and public health, the greatest potential to increase population-level physical activity might be through creation of supportive policies in other sectors. Global megatrends in information and communication technologies and transportation seem to have important effects on physical activity directly and by potentiating inter vention strategies.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Key messages

- Non-communicable diseases account for 60% of deaths globally, and 80% of these deaths occur in low-income or middle-income countries
- Physical inactivity is one of the major risk factors for non-communicable diseases, accounting for an estimated 3·2 million deaths per year
- The challenges and opportunities in prevention of non-communicable diseases show several important megatrends—major forces in societal development that are likely to shape people's lives in the next 10–15 years
- Information and communication technologies in the form of internet and mobile phone access have grown enormously during the past decade; these technologies have the potential to affect physical activity
- Trends in transportation, including the growth in ownership and use of private cars and improved and well integrated public transit systems, have the potential to both negatively and positively affect participation in physical activity, especially walking
- On the basis of a review of publications about physical activity interventions, we modelled the effects of megatrends in internet access, mobile phone access, and car ownership on physical activity
- The direct and potentiating effects of mobile phone technology on physical activity in middle-income and upper-income countries are similar in size to the mean effects of planned physical activity interventions in community and clinical settings
- The greatest potential for increasing population physical activity might be in the creation of supportive policies in sectors outside health (transportation, urban planning, and communication)
- There is a glaring mismatch between where the studies of physical activity interventions have been done and where the potential lies for population-level effects that will truly affect global health (low-income and middle-income countries)

Panel 1: Case study: urban transformation in Bogotá, Colombia

Bogotá has implemented broad policy and infrastructure changes to improve public space and transport. These urban and social changes have enhanced the environment for walking and cycling, improved public transport, and increased public safety. Bogotá is now widely known for the TransMilenio bus rapid transit (BRT) system and weekly street closures for recreation (Ciclovía). The TransMilenio and Ciclovía are associated with increased physical activity[82,86] and are promising models for intersectoral promotion of physical activity.[85,87] TransMilenio buses operate in exclusive lanes, have fixed stations, serve 1·4 million people daily, and are generally the fastest means of moving around Bogotá. Cross-sectional studies show that neighbourhood access to BRT is positively associated with walking for transport[87] and walking during leisure time.[85] These associations might also be attributable to parallel improvements in infrastructure, including pavements, pedestrian crossings and bridges, connecting cycle routes, and signage.

The Ciclovía is a free community programme in which 97 km of streets are closed for 7 h on Sundays and holidays allowing access to pedestrians, runners, rollerbladers, and cyclists. Participation in the Ciclovía ranges from 600 000 to 1 400 000 users per event, and annual costs are about $1·7 million. The Ciclovía engages nine sectors: education, environment, health, police, sports, culture and recreation, transport, urban planning, and local government. In a country with substantial social inequity, the Ciclovía is notable in that 90% of the participants are from low and middle socioeconomic strata. Adults who report participating in the Ciclovía are more likely to meet weekly physical activity recommendations and to use bikes for transportation than are those who do not participate.[85] A 2009 survey suggested that 15% of Ciclovía participants would otherwise be spending their time on sedentary behaviours if the Ciclovía was not available.[88] The Ciclovía is estimated to provide 13·6% of the recommended population requirement for weekly minutes of physical activity for Bogotá, while needing minimum investment in infrastructure. A cost-benefit analysis of the Ciclovía in Bogotá yielded benefit-to-cost ratios of 3·23–4·26.[89] Implementation of government-supported programmes such as the Ciclovía in existing public spaces seems to be a cost-effective means to increase physical activity. Ciclovías are now in more than 100 cities in the Americas and seem to have the right combination of effectiveness, feasibility, and political appeal to become a mainstay of global physical activity promotion.

Panel 2: Case study: texting to promote physical activity

The use of short-messaging services (SMS or text messaging) has risen as a low-cost way to deliver reminders and information to large numbers of individuals wishing to change their health-related behaviours, including physical activity. Although the reliance on some technologies might exclude people from low socioeconomic backgrounds, the use of mobile phones has substantially increased in recent years in low-income populations in most parts of the world, making SMS a channel with potential broad reach to underserved populations.[51] A study in Australia used an SMS-based intervention to increase physical activity in postnatal women, a population at high risk of inactivity, and specifically recruited women from communities with high representations of single-parent families and low education, and low-income households.[49] Participants received 42 text messages during the 13-week intervention that contained personally tailored behavioural and cognitive tips for increasing activity, ranging across themes from social support to physical activity opportunities in their neighbourhoods. Across the 13 weeks, those who received text messaging significantly increased their frequency of moderate-to-vigorous physical activity and frequency of walking for exercise. These participants also reported significantly greater min per week of walking for exercise than those who did not receive the SMS reminders.

Mobile phone use is also increasing in low-income and middle-income countries, drawing attention to text messaging as a channel with large potential global reach.[47,48] Harnessing the growing reach of mobile phones in countries with low and middle incomes, the Kenyan WelTelKenya project implemented an SMS-based intervention to increase adherence to antiretroviral treatment (ART) in new HIV-infected patients.[99] Although most participants (76%) lived on less than US$5 per day, 87% owned their own mobile phone and the remaining 13% had access to a phone. For a year, participants in the intervention group were sent one text message per week inquiring about their status, if they had any problems, and asking them to respond within 48 h. Adequate adherence (taking >95% of pills) was reported in 62% of the intervention group compared with 50% of the standard care group, and was accompanied by a significant decrease in disease outcomes. In view of the high cost of ART drugs, the inclusion of SMS seems to be an especially cost-effective way to improve adherence and to potentially improve public health. With the high prevalence of both physical inactivity and mobile phone access in low-income and middle-income countries, SMS-based interventions to initiate and maintain physical activity in these countries seem quite promising.

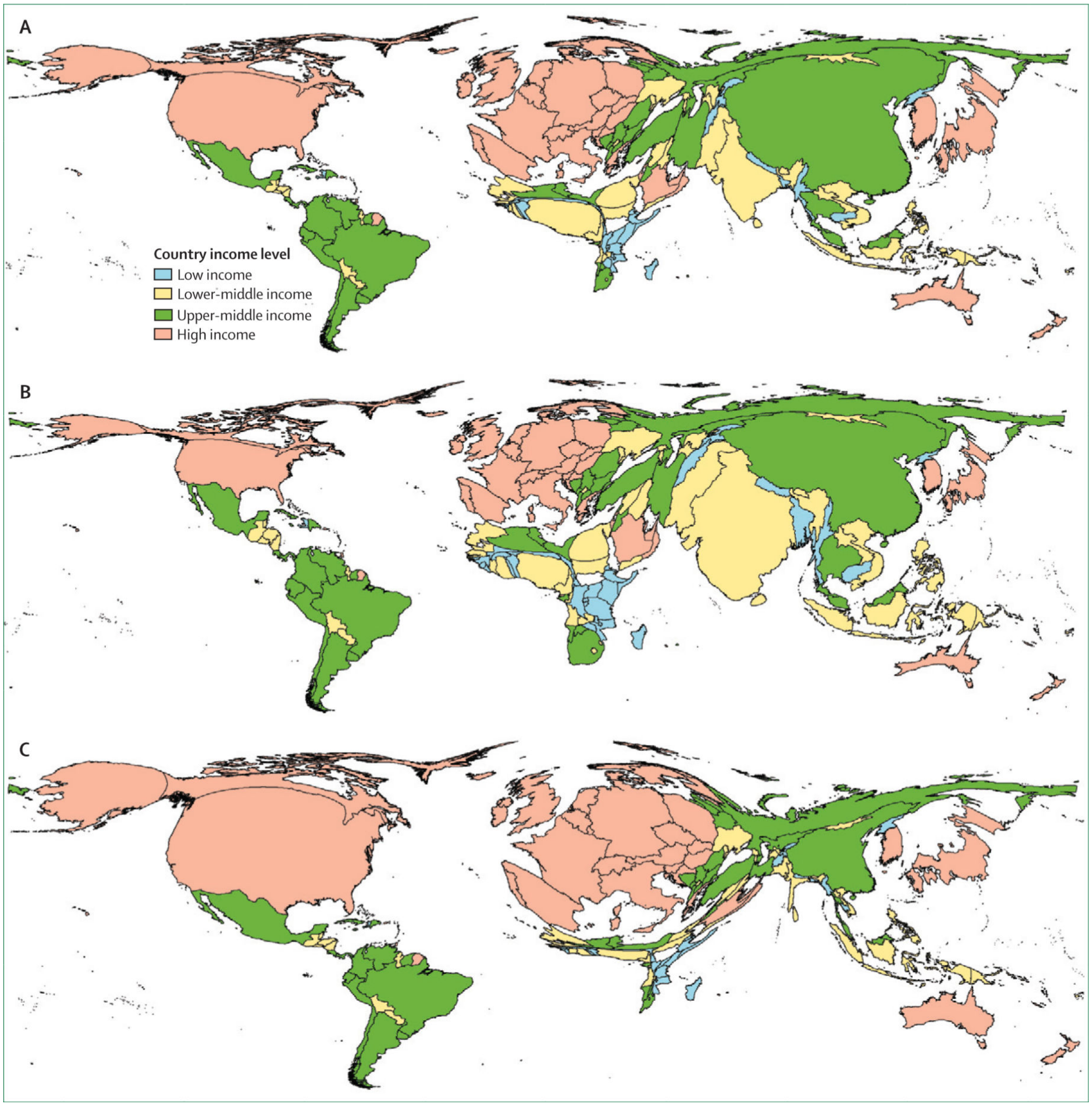

Figure 1. Internet users (A), mobile phone users (B), and car ownership (C), by country income

Each country in this density-equalising map is resized according to the number of internet or mobile-phone users or car owners with the Gastner and Newman algorithm.[62]

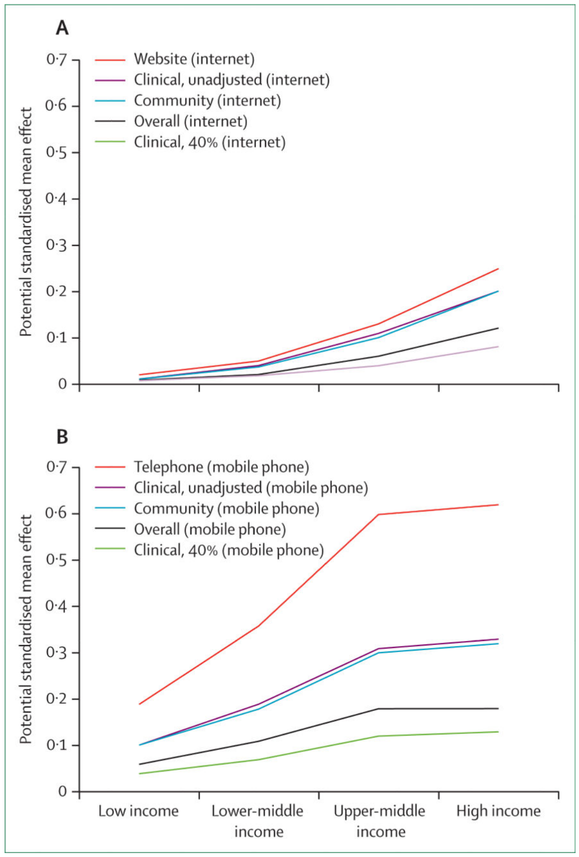

Figure 2. Potential effect estimate for information and communication technologies

(A) Internet. (B) Mobile phone. Clinical=interventions in a health-care setting.

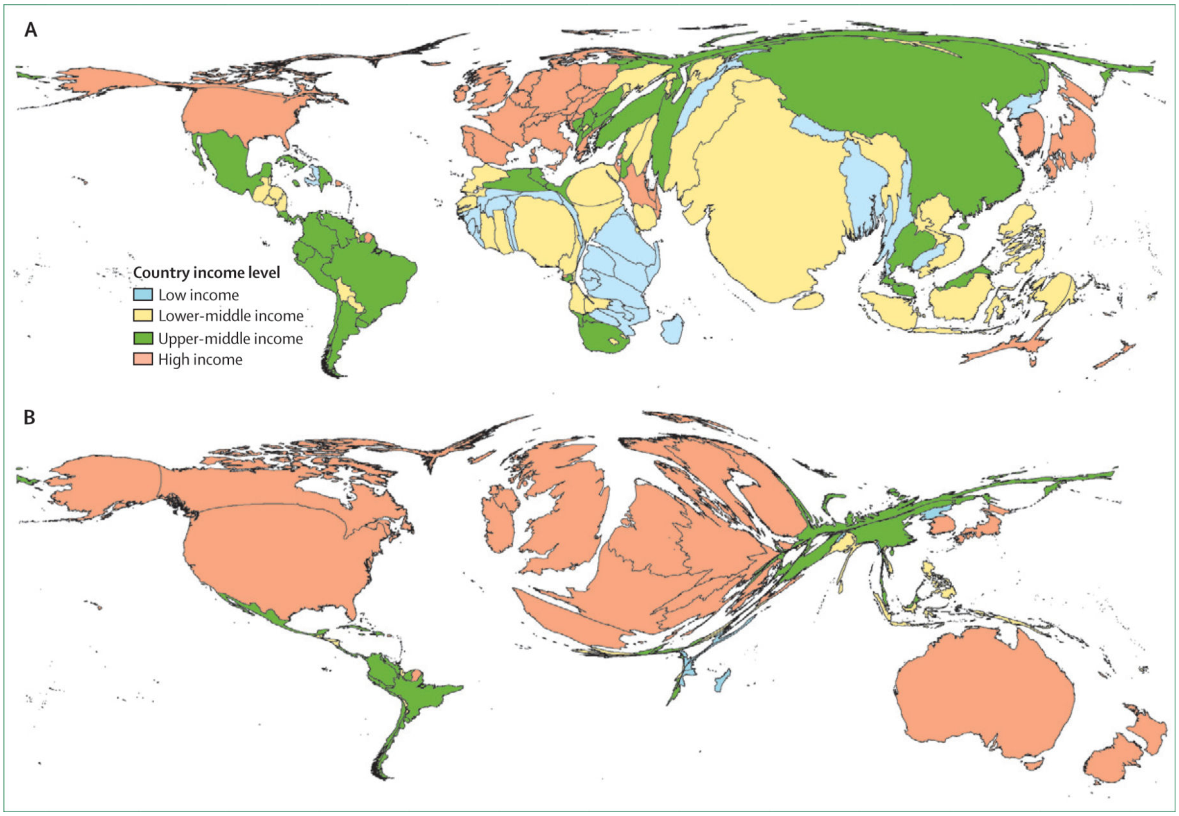

Figure 3. Mismatch between world population and evidence for physical activity interventions as measured by scientific publications

Countries in this density-equalising map are resized according to country population (A) and number of times a country is reported to be included in a review (B).

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Table 1

Potential effect of the internet on physical activity interventions (based on effect estimates from web-based physical activity interventions and other physical activity interventions) and the potential effect of mobile phones on physical activity interventions (based on effect estimates from telephone-based physical activity interventions and from other physical activity interventions), by country income

	Low income	Middle income	Lower-middle income	Upper-middle income	High income
Internet					
Overall					
SME	0·01 (0·17)	0·06 (0·09)	0·02 (0·03)	0·06 (0·07)	0·12 (0·12)
Mean effect (min per week)	0·61 (1·20)	4·76 (5·99)	1·71 (2·32)	4·68 (4·50)	8·88 (7·42)
WPE (min per week)	0·07	3·44	0·62	1·68	1·46
Website interventions					
SME	0·02 (0·03)	0·13 (0·13)	0·05 (0·05)	0·13 (0·08)	0·25 (0·11)
Community interventions					
SME	0·01 (0·02)	0·11 (0·10)	0·04 (0·04)	0·11 (0·06)	0·20 (0·07)
Clinical interventions					
SME, population-wide effect 2·6%	0·00 (0·00)	0·00 (0·00)	0·00 (0·00)	0·00 (0·00)	0·01 (0·00)
SME, population-wide effect 40%	0·01 (0·01)	0·04 (0·04)	0·02 (0·01)	0·04 (0·02)	0·08 (0·03)
SME, unadjusted	0·01 (0·02)	0·11 (0·09)	0·04 (0·04)	0·10 (0·06)	0·20 (0·07)
Mobile phones					
Overall					
SME	0·06 (0·07)	0·14 (0·14)	0·11 (0·14)	0·18 (0·16)	0·18 (0·17)
Mean effect (min per week)	4·37 (5·72)	10·96 (10·91)	8·22 (10·91)	13·52 (12·45)	14·03 (12·67)
WPE (min per week)	0·51	7·91	2·98	4·87	2·27
Telephone interventions					
SME	0·19 (0·15)	0·48 (0·22)	0·36 (0·22)	0·60 (0·21)	0·62 (0·20)
Community interventions					
SME	0·10 (0·07)	0·25 (0·09)	0·19 (0·09)	0·31 (0·06)	0·33 (0·04)
Clinical interventions					
SME, population-wide effect 2·6%	0·00 (0·00)	0·01 (0·00)	0·00 (0·00)	0·01 (0·00)	0·01 (0·00)
SME, population-wide effect 40%	0·04 (0·03)	0·10 (0·03)	0·07 (0·04)	0·12 (0·02)	0·13 (0·02)
SME, unadjusted	0·10 (0·07)	0·25 (0·109)	0·18 (0·09)	0·30 (0·05)	0·32 (0·04)

Data in parentheses are SD. SME=standardised mean effect. WPE=potential effect weighted by population distribution.

Table 2

Potential effect of car ownership on active travel min per day, by country income

	Low income	Middle income	Lower-middle income	Upper-middle income	High income
PET	–0·123	–0·786	–0·477	–0·798	–3·114
SD	0·137	0·816	0·383	0·816	2·084
WPE	–0·016	–0·555	–0·271	–0·110	–0·500
Fuel increase, short term					
PEF	0·001	0·008	0·005	0·008	0·031
WPEF	0·000	0·014	0·007	0·003	0·013
Fuel increase, long term					
PEF	0·003	0·020	0·012	0·020	0·078
WPEF	0·000	0·014	0·007	0·003	0·013

PET=potential effect of car ownership on active travel time (min per day). WPE=weighted potential effect, by population distribution. PEF=potential effect of 10% fuel price rise on daily min of physical activity. WPEF=weighted potential effect, by population distribution, of 10% fuel price rise on daily min of physical activity.