Based on data from the Netherlands, Denmark, USA and UK, Jacobsen's paper in 2003 identified the non-linearity between the number of cyclists and pedestrians and the risk of injury from being hit by a motor vehicle. In other words, the more people walked and cycled the fewer the number and rate of traffic collisions and injuries experienced by cyclists and pedestrians – a non-linear relationship. Jacobsen, termed this relationship, 'Safety in Numbers' (SIN), which was shown at different levels of scale, whether at an intersection, a city or a country. More recent work has since shown SIN to occur in other countries such as Australia. [1] (Robinson, 2005).

The (SIN) effect quickly grabbed the attention of public health promoters who were seeking ways to promote active travel, including walking and cycling. Efforts to address growing levels of obesity and inactivity in the developed world were, and still are, underway and the concept of SIN was seen to support the clarion calls for measures to promote the number of walkers and cyclists. SIN was also seen as a support by those demonising any measure that might deter the numbers of those walking and cycling, such as the mandatory use of cycle helmets. In fact, people who campaigned for increasing helmet use were lambasted and accused of potentially increasing serious injuries amongst cyclists by reducing the SIN effect. It is probably the public health fraternity who have done much to increase the impact this paper, more so than those concerned with injury prevention and/or transportation safety. Arguably, the Jacobsen paper led to a paradigm shift among planners and engineers who could think about pedestrian and bicycle safety in a different way and not be so fearful that by encouraging increases in walking and cycling they would see an increase in traffic collisions and casualities.

SIN was exciting because it raised questions of why this phenomenon occurred, what did it represent? What were the causal mechanisms? In fact, the causal interpretation that the inverse association between the number of cyclists or pedestrians and the rate of traffic collisions and injuries, results from improved behaviour of motorists, is the most contentious aspect of Jacobsen's paper, and yet to be substantiated. Others have argued , that SIN occurs because of an increase in the number of drivers who are also cyclists and who are therefore more likely to be sympathetic to cyclists and extra cautious in their presence. It is more likely that the SIN effect may be explained in terms of a complex interplay between a number of variables such as safety, infrastructure, laws, and culture. For example, the introduction of the congestion charge in London in 2003, led to an overall decrease of 10% in traffic volumes over 10 years, an increase in pedestrians and cyclists and a reduction in casualties, reported by Transport for London (2006), [2] though this has been challenged by Noland et al in 2008, [3] who reported possible increases in cyclist casualties within the congestion charging zone.

As reported by Elvik el al, [4] and Bhatia and Wier, [5] it is unlikely that the effect of SIN is an emergent property of the sheer numbers of cyclists or pedestrians, but more likely to be an effect of significant investments in measures that make cyclists and pedestrians feel safe, such as dedicated infrastructure and the enforcement of laws that regulate how pedestrians, cyclists and motorists behave on the roads. These kinds of investments are expressions of a country's political will to improve safety for pedestrians and cyclists, and as such, the SIN effect may be a reward for this, or the effect may in fact be in the opposite direction. That is, that those places less risky for pedestrians and cyclists may be the places where more people walk and cycle. Previous research has demonstrated a preference by pedestrians for lower speeds, lower traffic volumes and greater separation between pedestrians and motorists (Landis et al, 2001; Jacobsen et al, 2009), [6,7] while

Pucher and Beuhler (2008), [8] have shown the importance of safe dedicated cycling infrastructure as a key to achieving high levels of cycling.

The success of safer cycling in the Netherlands can be seen as systematic effort by successive governments to improve cycling safety. Cycling was not always safe in the Netherlands until the government took radical action to invest in dedicated cycling infrastructure. Figure 1 illustrates the strong relationship between levels of cycling and cycling fatalities, in particular, the sharp decline in cycling fatalities after the mid- to late-1970s, when significant investment was made in cycling infrastructure and policy development. Pucher and Buehler (2008) argued that the safety and popularity of cycling was achieved through policies that restricted car use and more than doubled the bikeway network including a significant network of separate paths (Berlin 860 km, Amsterdam 400km and Copenhagen 400km). The provision of separate facilities for cyclists has been described as the 'cornerstone of policies to make cycling safe, comfortable and attractive for all' (Pucher and Buehler, 2008).

However, there needs to be a strong note of caution in concluding that as long as the collision risk is going down then cycling is safe for all. We must remember that the data is based on police reported casualties, those that involve a vulnerable road user and a mechanically propelled vehicle. This figure excludes the large and growing number of single crashes that occur on the public highway involving cyclists that are not reported to police (Schepers et al, 2011). [9] Recent Swedish casualty figures based on the comprehensive STRADA register, which combines police and hospital reported casualties, show that eight out of ten injured cyclists result from single crashes not involving a collision with a motor vehicle (Niska and Eriksson, 2013) [10]. However, in most European countries, there is evidence of severe underreporting of such incidents (Reurings et al 2011; Wegman et al 2012). [11-12] These crashes go under the 'epidemiological radar' but need to be taken into account as they are a public health concern. The role of secondary safety such as helmets may have a role to play in mitigating the consequences of such crashes.

Implied in the SIN concept is that cyclists and pedestrians travel in proximity with each other and that the protective effect is similar to the protective effect of animal herds. Animal herds that are at risk of predation make use of SIN by diluting risk to individual animals, and through collective vigilance. It might be that people walking or cycling together may provide a degree of protective vigilance in watching out for each other, or the group of walkers or cyclists may present a visual cue to motorists to slow down and drive with greater awareness of the group's behaviour. However, the question as to whether pedestrians and cyclists also benefit from the protective effects of travelling as a herd is yet to be carefully studied. We also need to think about 'who' is safe in numbers? Some countries such as the Netherlands and Germany have achieved roughly even numbers of males and females cycling. However, whilst London has seen a significant increase in the number of cyclists the demographic profile of cyclist does not reflect the population – it is dominated by white, middle class, middle aged men (Steinbach et al, 2011) though there is an over representation of women among the fatalities (Talbot et al , 2014). [13-14]

There is a further potential flaw in the SIN concept. If the logic is that the more people walk or cycle the safer they are how does this explain the relative high risk of injury among pedestrians and cyclists from deprived areas, where we know people walk more because there is less access to a car? (Christie, 1995; Graham et al, 2005; Lyons et al 2004). [15-17] Much of this excess risk has been

attributed to the hazardous nature of the road environments in deprived areas and changing these has been shown to reduce risk (Jones et al, 2005). [18]

So we cannot be complacent about pedestrian and cycling safety, especially with regard to single crashes. Safety in Numbers is likely to represent an effect of significant investment in system-wide measures that encourage walking and cycling because they make it feel safer, such as dedicated infrastructure provision. Jacobsen's paper gave hope that by increasing the numbers that walk and cycle, it could be made safer through the reduction of pedestrian- and cyclist-collisions. However, assuming a causal direction from increased numbers of pedestrians and cyclists to improved motorist behaviour, merits further research. Looking to the future we need a greater understanding of *how* SIN is achieved; whether it is a causal relationship, as implied by Jacobsen; what in fact works as underlying mechanisms; for whom and under what circumstances does SIN protect pedestrians and cyclists. While these efforts to understand SIN are underway, there is much that we know within a Safe Systems Approach to road safety, about how to make environments safer for pedestrians and cyclists – whether they travel as individuals or in groups. Creating safer environments, which include dedicated infrastructure and separation from motor traffic, is likely to achieve the desired effect to reduce pedestrian and cycling collisions, fatalities and disabilities.

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