Objective: To systematically identify the various methods of speed management and their effects.

Methods: A systematic search was performed in Science Direct, Ovid Medline, Scopus, PubMed and ProQuest databases from April to June 2015. Hand searching and reference of selected articles were used to improve article identification. Articles published after 1990 which had reported on efficacy/effectiveness of speed management strategies were included. Data were extracted using pre-defined extraction table.

Results: Of the 803 retrieved articles, 22 articles were included in this review. Most of the included articles (63%) had before-after design and were done in European countries. Speed cameras, engineering schemes, intelligent speed adaption (ISA), speed limits and zones, vehicle activated sign and integrated strategies were the most common strategies reported in the literature. Various strategies had different effects on mean speed of the vehicles ranging from 1.6 to 10 km/h. Moreover, 8-65% and 11-71% reduction was reported in person injured accidents and fatal accidents, respectively as a result of employing various strategies.

Conclusion: Literature revealed positive effects of various speed management strategies. Using various strategies was mostly dependent on road characteristics, driver’s attitude about the strategy as well as economic and technological capabilities of the country. Political support is considered as a main determinant in selecting speed management strategies.

Keywords: Speed management; Speed reduction; Effectiveness; Traffic.
have reported that lower speed variance is correlated with fewer crashes [8,9]. Also, it was declared that 1 km/h reduction in speed would lead to 3% and 4-5% decrease in accidents with injuries and risk of death in crashes, respectively [10]. So, speed management has been turned into a challenge for countries [11].

Speed management is not only about regulating the speed but also to plan and design appropriate road layout and networks to obtain the proper speed [12]. Various strategies were used for speed management including traditional methods such as advisory speed posting, speed limits and road design as well as modern methods such as intelligent speed adaptation, safety cameras, support via an active accelerator pedal and other strategies [1,2,13]. Studies have demonstrated substantial difference, in traffic accident rate reduction and speed changes, among various approaches [1,14]. It was reported by previous studies that various speed management strategies had an effect of -2.4 to -10 (mph) in mean speed and reduction in person injured accidents (PIAs) ranging from -9% to -58% [14-18]. Elvik (2013) revealed that reducing speed limits had a positive effects on reducing number of crashes [19]. As well as, Ayuso et al. concluded that the risk of accident increases with exceeding speed limits [20].

Various speed management strategies with different levels of effect have been used to control vehicles’ speed and improve traffic safety. Identifying these methods as well as their effects and implementation characteristics could provide useful information to make decision about using the methods. The aim of this study was to systematically review the various speed management strategies and their effects.

Materials and Methods

Using a systematic method, this review was done by searching the keywords; speed management, speed reduction and combined through strategy, method, policy, plan and program. Literature search was done using Science Direct, Ovid Medline, Scopus, PubMed and ProQuest databases. Manual search of journals were done. Also references of the selected articles were reviewed to increase the chance of articles finding. The inclusion criteria were: publications in a peer reviewed journal, in English and with focus on speed management strategy and its effects. Articles which had measured the effect of speed management strategies on air pollution, driver’s perception about speed management strategies as well as conference presentations and qualitative studies were excluded from the review.

Articles were first screened reviewing their titles in order to exclude non-relevant articles. Then the abstract and full texts of the retained articles were reviewed. Endnote X5 software was used for organizing, title and abstract reviewing and also identification of duplications. Extraction table was used to extract the data from the included articles.

Retrieved Content

Totally 793 articles were retrieved through electronic search. Duplicates were excluded and 10 extra articles were added by hand searching and checking the reference of references. Actually 22 articles were included in the study. The article retrieval diagram is reported in Figure 1.

![Figure 1. Article review and retrieval diagram](image-url)
Most of the included articles (63%) had before-after design and were done in European countries. Speed cameras, engineering schemes, intelligent speed adaption (ISA), speed limits and zones, vehicle activated sign and integrated strategies were the speed management strategies reported by the literature. The results of included studies are presented in Table 1.

**Speed Cameras**

One of the most common speed management strategies was the use of speed cameras [14,21]. Studies had reported a reduction in person injured accidents (PIAs) after introduction of speed cameras ranging from 4% in London to 51% in South Wales, UK [15-18,22,23]. Novoa et al. had reported 30% and 26% reduction in risk of crashes and people injured in Barcelona, respectively [24]. Similarly, Carnis and Blais (2013) in an assessment of the French speed camera program, revealed reduction in fatal and non-fatal traffic injuries. They had reported 21% reduction in fatality rate per 100000 vehicles [25]. A four year evaluation of speed cameras effectiveness in London showed 5.3 miles/h reduction in average speed for fixed camera sites. This was 1.4 and 1 miles/h for mobile cameras in urban and rural roads, respectively [21].

Most of the studies had reported that speed cameras were effective intervention in reducing vehicles speed, the number of crashes and consequently, the number of traffic injuries or fatalities[21,22,26,27]. Regarding these confounding factors, follow up length had confounding effects on speed cameras’ effectiveness measurement [21]. Moreover, type of used metrics and measurement circle range (distance from speed camera) affects effectiveness of the speed cameras [17,25]. Different study parameters had led to heterogeneity in literature and poor methodological rigor was seen in some speed cameras effectiveness studies [21]. Future studies must pay more attention to control the affecting factors.

**Engineering Schemes**

Engineering schemes or measures includes physically changing the layout of the road to reduce the vehicles speed [28]. Engineering schemes are in two major groups, schemes with vertical deflections and horizontal deflections. Mountain et al. (2005) revealed that schemes with vertical deflections had the most reduction in accidents compared with speed cameras and schemes with horizontal deflection. It was reported that vertical deflecting schemes had led to 44% and 35% reduction in PIAs and FSAs, respectively. Moreover, vertical and horizontal deflecting schemes had shown reduction of 8.4 and 3.3 mph in mean speed of vehicles [27]. Literature revealed that horizontal schemes were less effective that vertical ones, however their impact become synergistic when used in combination [14,27,29].

**Intelligent Speed Adaptation (ISA)**

Intelligent speed adaptation (ISA) refers to any system that did not allow the vehicle to exceed the safe or legally enforced speed. In a speeding situation, the vehicle speed is automatically reduced (active) or the driver could be alerted (passive) [30,31]. ISA helps the drivers to maintain a legal and safe speed along the driving time. Passive methods (such as beeps, buzzers, earcons and visual and auditory messages) had reported with a positive effect on drivers’ speed limits compliance [32-36]. However, study results showed that young drivers were not satisfied by visual and auditory messages [33,37].

Studies reported significant decrease in vehicles speed using active ISAs such as active accelerator pedal (AAP) [13,38,39]. Moreover, drivers thought of AAP as a useful idea [40]. Emeli Adell et al. had reported about 4 km/h reduction in mean speed of the vehicles using AAP [13]. Also in Malaysia AAP had led to 1.6 km/h reduction in mean speed and in UK it was the reason of 10% reduction in PIA crashes [41]. Determining the effect of ISA on traffic accidents is difficult. Because the proportion of ISA equipped vehicles in studies were relatively small. Moreover, it is clear that the size of effects depends on ISA type [42].

**Speed limits and Zones**

Road speed limits are commonly used speed management method in most countries which are set by the legislative bodies and enforced by police. Speed limits are based on road characteristics and surroundings such as road surface, curvature, width and so on [43,44]. Pervious studies had reported that if the speed limit was not compatible with the road characteristics, drivers did not comply with it [45,46]. Jongen et al. had reported that setting a lower speed limit could be a useful method for speed reducing but the speed limit signs must repeat more frequently in the zone [43]. In a study by Grundy et al. (2009), it was revealed that introducing 32km/h speed limit had led to 41.9% reduction in road casualties [47]. Literature had proved the effect of reducing the speed on reducing crashes and injuries [5,48,49].

**Vehicle Activated Sign**

Vehicle activated signs (VAS) are a type of traffic signs mainly as speed limit advisory and hazard warning signs. The signs deployed on roadsides alert the drivers about speed limit and danger situations [50-52].

Pervious studies have reported a positive and significant effect of the activated signs on drivers speeding behavior and traffic safety [53]. Winnett MA et al. study results illustrated 2.6-7.1% reduction in mean speed of vehicles and 31% decrease in PIAs [54]. In a review by Nygårdh reduction in mean speed and accidents was reported [55]. However, Tay et al. had reported that introducing the activated signs in an inter-city highway, had increased the
<table>
<thead>
<tr>
<th>N</th>
<th>Author</th>
<th>Date</th>
<th>Country</th>
<th>Study design</th>
<th>Speed management method</th>
<th>Effects on Speed</th>
<th>PIAs&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>L.J. Mountain et al. [27]</td>
<td>2005</td>
<td>UK</td>
<td>Before-after</td>
<td>Safety cameras</td>
<td>-4.1 (mph)</td>
<td>-22%</td>
<td>-11%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Engineering schemes incorporating vertical deflections</td>
<td>-8.4 (mph)</td>
<td>-44%</td>
<td>-35%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Engineering schemes incorporating horizontal deflections</td>
<td>-3.3 (mph)</td>
<td>-29%</td>
<td>-14%</td>
</tr>
<tr>
<td>2</td>
<td>Rinusaarsma et al. [2]</td>
<td>2011</td>
<td>Netherlands</td>
<td>Controlled study</td>
<td>“low cost designs” in 60 km/h speed limit roads</td>
<td>-</td>
<td>-2.4%</td>
<td>-2.7%</td>
</tr>
<tr>
<td>3</td>
<td>Md. Tazul Islam et al. [57]</td>
<td>2013</td>
<td>Canada</td>
<td>Controlled experimental study</td>
<td>Integrated speed management strategy (education, enforcement activities, low cost engineering treatment)</td>
<td>-2.94 km/h (5.8%) and -2.26 km/h (4.5%) for the short term and long term, respectively</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>A. Martinez, D.A. Mantaras, P. Luque [61]</td>
<td>2013</td>
<td>Spain</td>
<td>before-after experimental design</td>
<td>low-cost solutions (Correcting the speed limit, Transversal white lines, Reflecting “cat’s eye” road studs, Linear delineation system for the crash barrier, Reflecting barrier studs, High visibility panels)</td>
<td>7.1% in the average speed and -7.6% in the 85th percentile of the speed immediately after the experiment.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Emeli Adell et al. [13]</td>
<td>2008</td>
<td>Spain, Hungary</td>
<td>Field experiment before/during/after study</td>
<td>ISA (intelligent speed adaptation) (Support via an active accelerator pedal (AAP) and (2) warning via beep signals and a flashing red light when the speed limit was exceeded (BEEP).)</td>
<td>For 30 km/h streets (2.8 and 3.9 km/h reduction in mean speed)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Ahmad Khushairiy Makhtar [39]</td>
<td>2012</td>
<td>Malaysia</td>
<td>before-after experimental design</td>
<td>Intelligent Speed Adaptation (ISA)</td>
<td>-1.6 km/h average speed of participants</td>
<td>-10 % with an advisory system -20–40 % with a system that enforces current speed limits</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Andras Varheleyi [41]</td>
<td>2002</td>
<td>Swedes-UK</td>
<td>experimental</td>
<td>In-car devices (in-car feed-back, in-car information, in-car speed supervisor, “intelligent” gas pedal)</td>
<td>----</td>
<td></td>
<td></td>
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<tr>
<td>8</td>
<td>Kurt Ron Smith [62]</td>
<td>2011</td>
<td>US</td>
<td>before-after</td>
<td>Various strategies (Speed limits, enforcement, speed enforcement by automation, speed control strategies without enforcement, traffic calming strategies for speed control)</td>
<td>Approximately 55% (106 sites) of the locations assessed had a statistically significant reduction in mean speeds during 2006-2010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Lene Herrstedt [63]</td>
<td>1992</td>
<td>Denmark</td>
<td>An extensive effect evaluation study</td>
<td>Traffic management method called “Environmentally adapted through road.”</td>
<td>8 to 10 km/h reduction in mean speed of the vehicles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Rune Elvik [49]</td>
<td>2001</td>
<td>Meta-analysis</td>
<td>Meta-analysis</td>
<td>Urban traffic calming schemes</td>
<td>----</td>
<td>-15%</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Author(s)</td>
<td>Year</td>
<td>Location</td>
<td>Methodology</td>
<td>Device(s)</td>
<td>Reductions</td>
<td>Notes</td>
<td></td>
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</tr>
<tr>
<td>11</td>
<td>R. Ando [64]</td>
<td>2014</td>
<td>Japan</td>
<td>Experimental-simulator</td>
<td>Intelligent Speed Adaptation (ISA)</td>
<td>-----</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Ellen De Pauw et al. [22]</td>
<td>2013</td>
<td>Belgium</td>
<td>Before-After evaluation</td>
<td>Fixed speed cameras</td>
<td>-----</td>
<td>-8% -29%</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Chris Grundy [47]</td>
<td>2009</td>
<td>UK</td>
<td>Observational study</td>
<td>20 mph (32 km an hour) traffic speed zones</td>
<td>-----</td>
<td>----- -41.9%</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Paul Pilkington [23]</td>
<td>2005</td>
<td>--</td>
<td>Systematic review</td>
<td>Speed cameras</td>
<td>12% to 65% reduction</td>
<td>-17% to -71%</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>L.J Mountain et al. [16]</td>
<td>2004</td>
<td>UK</td>
<td>Before-After</td>
<td>Speed cameras</td>
<td>-4.4</td>
<td>-26% -34%</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>West London report [65]</td>
<td>1997</td>
<td>UK</td>
<td>Before-After</td>
<td>Speed cameras</td>
<td>-</td>
<td>-8.1% -55.7%</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Stephane Hess [66]</td>
<td>2004</td>
<td>UK</td>
<td>Speed limit enforcement cameras (SLECs)</td>
<td>-</td>
<td>-45.74% in the immediate vicinity of the camera sites</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Richard Allsop [21]</td>
<td>2010</td>
<td>--</td>
<td>review</td>
<td>Speed Cameras</td>
<td>-● 5.3 miles/h at fixed sites -● 1.4 miles/h at mobile urban sites -● 1.0 miles/h on average at mobile rural sites</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Adrian Gains et al. [67]</td>
<td>2005</td>
<td>UK</td>
<td>Before-fter</td>
<td>Speed and red-light cameras (safety cameras)</td>
<td>6% reduction -2.3mph in average speed</td>
<td>-22% -42%</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>M.A Winnett [54]</td>
<td>2002</td>
<td>UK</td>
<td>Before-After with control</td>
<td>Vehicle-activated signing (Speed limit mundel (just inside the speed limit terminal signs) - mainly village sites. _Bend warning. _Junction warning. _Safety camera repeater sign (displaying camera logo.)</td>
<td>-4mph in mean speed (reduction in the mean speed of between 2.6 and 7.1mph)</td>
<td>-31%</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>S.M Christie et al. [17]</td>
<td>2003</td>
<td>UK</td>
<td>Controlled before and after study</td>
<td>Mobile speed cameras</td>
<td>-</td>
<td>-51%</td>
<td></td>
</tr>
</tbody>
</table>

*Person Injured Accidents (PIAs); *fatal and serious accidents (FSAs)*
likelihood of speed limit obedience in a small group of the drivers [56].

**Integrated Strategies**

Introducing speed management integrated strategies in roads would benefit the advantage of each strategy. Islam et al. had implemented an integrated speed management plan including educational activities, dynamic massage signs as well as enforcement and low cost engineering schemes. They had reported 5.8% and 4.5% reduction in mean speed, in short term and long term, respectively [57]. However, some studies had illustrated differing and time contradictory results for effectiveness of delineation methods combination [58,59]. Yannis et al. had concluded that an integrated speed management plan, to be effective and successful, depends not only on systematic monitoring of plan implementation and road safety but also needs strong political support of the local governments [60].

**Conclusion**

Most of the studies had reported positive effects of various speed management strategies on drivers speeding behavior and road safety. Selecting an appropriate speed management strategy depends directly not only on the road characteristics but also on the political support and community capacity (such as economical, technological, information management power, road safety related organizations ability as well as drivers attitude) about the specific strategy. Retrieved studies showed that developed countries had good experiences of speed management as a national and international priority. Their experiences illustrated that as a controversial issue, speed management needs political support as a driver of the strategies. This issue has more importance in developing countries. Considering variety of factors potentially affecting the effectiveness of speed management strategies, it is highly recommended to conduct national and regional studies on speed management in low and middle income countries. Moreover, developing and implementing a speed management strategy must be based on speed and road safety data to be measurable. However, defining an appropriate combination of effectiveness measures must consider the local circumstances.

**Acknowledgment**

The study was done under the support of Road Traffic Injury Research Center of Tabriz University of Medical Sciences.

**Conflict of Interest:** None declared.

**References**


