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Elaboration of Explanatory Factors of Accidents in Cameroon by Factorial Correspondence Analysis

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Abstract

The aim of this paper is to examine the causes of road accidents in Cameroon. The Douala-Yaoundé highway was chosen as the case of study. Available field data recorded from the year 2006 to 2011, have enabled the analysis of each accident. The method used here is the factorial correspondence analysis; which aims to bring in a small number of dimensions, most of the initial information, focusing not on the absolute values, but the correspondence between the variables, that is to say the relative values. From this analysis, it appears that, of the 906 accidents recorded during this period, top five causes account for nearly 83% of the information provided by the set of variables on the occurrence of road accidents. These causes are: driver inattention, lack of control, over speeding, improper overtaking and tire puncture. These results require involvement in the construction of road safety policies through training, sensitization and adequate repressions as well as administrative reforms and research policy in road safety.

Keywords

Road Accident, Road Safety, Factorial Correspondence Analysis, Accidental Variables, Accidents Explanatory Factors

1. Introduction

Today, road accidents remain a blight both for public authorities in all countries around the world and for international organizations. Indeed, according to the WHO [1] about 1.35 million people are killed on the roads worldwide. More specifically in Africa, road accidents are the second leading cause of death after malaria. Thus, Africa accounts for about 27% of the 1.35 million deaths worldwide for just over 2% of vehicles [1]. This situation can be explained by a combination of several factors, the weight or importance of which varies from country to country.

In Cameroon, a middle-income country and therefore prone to road accidents [1], although the mortality rate has declined sharply from 28.1% in 2007 to 20.6% in 2015, road accidents remain the second leading cause of death after malaria [2]. In this context, although road accidents occur throughout the country, they are concentrated around three main roads due to the importance of the cities linked by them. As a result, road accidents have a very high socio-economic cost. In human terms, there have been just over 1000 deaths and over 6000 injuries. On the economic level, the economic losses suffered by Cameroon due to road accidents represent nearly 100 billion CFA francs per year, equivalent to 1% of the GDP of this period [3]. In the light of the above, it is becoming essential to conduct a study to identify the explanatory factors for road accidents in order to draw up a policy which, if it does not eliminate road accidents, will reduce them or provide a framework for their occurrence.

2. Literature Review

Road accident studies have shown that four main causal dimensions have been identified as contributing to the occurrence of an accident. These include driver behaviour, the environment, the vehicle and pedestrian behaviour. Each dimension includes the causes that are linked to it [4]. Several studies have been carried out for the causal analysis of accidents. Those based on the examination of reports or on the variation of behaviour according to causal explanations and beliefs, or those based on a quasi-experiment analysing the variation of causal explanations and attitude towards preventive measures, according to the situational relevance, personal relevance and severity of the accident, and these studies have given disparate results depending on the position of each analyst [4]. Causal explanations for accidents thus vary from one source to another depending on the analytical techniques used or the location.

In addition, several methods are commonly used for studying the causality of road accidents. Many of them are based on the collection of road accident data. The principle here is to group the accidents according to their profile for a good understanding of their production [5]. This method usually leads to a subjective analysis. This is why we are moving towards Correspondence Factory Analysis.

According to Grangé *et al.* [6], the studies carried out in this framework are based on the analysis of contingency tables, which makes it possible to study the links between two qualitative variables. Here we then have the possibility of reducing the dimension arising from the existence of correlation between the variables. In addition to descriptive statistical analysis, whose interest is recognised (quantification of the situations studied) but also some limitations (difficulty of crossing multiple data and interpretation), Factor Correspondence Analysis enables all the data (circumstances and characteristics of the accidents) to be cross-referenced/taken into account and to highlight their dependence/independence (correlation strength and significance) [7] [8]. In view of all these performances, it becomes obvious for us to approach this method in the framework of the present study in order to limit the dispersion of results observed.

3. Methodology

In order to analyse the causalities factors of road accidents, we use Factor Correspondence Analysis (FCA), which aims to gather most of the initial information in a reduced number of dimensions, focusing not on absolute values but on the correspondences between the variables [7]. This reduction is all the more useful if the number of initial variables is high. The notion of "reduction" common to all factor techniques has the particularity of providing a common representation space for variables and individuals. The goal of the CFA is therefore to read the information contained in a multidimensional space by reducing the dimension of this space while retaining a maximum of the information contained in the original space. To do this, the AFC uses the reduction or frequency table as the basis for its reasoning. This method makes it possible to compare the distance between the different responses modalities to the variables selected on axes whose significance is determined by the variables that characterize them. The CFA is used to determine and prioritize all dependencies between the rows and columns of the table. The total variance explained allows us to appreciate the amount of information explained by a factorial axis. It defines axes that best summarize the information obtained from the selected variables.

In our study, given the heteroscedasticity of the variables, it seemed appropriate to conduct an analysis of the correlations of the variables using the correlation matrix. It represents the correlation coefficients calculated on several variables taken in pairs. To assess the relationships between the variables and the factor axes, we used the post-rotation component matrix based on the varimax method with Kaiser normalization.

3.1. Choice of Road Sample

The road sample is the Yaoundé-Douala highway which is 242 km long. This road has been chosen for its heavy traffic (6000 vehicles/day) due to the economic and political importance of the towns it connects.

The road sample was subdivided into four sections (**Figure 1**):

Section 1: Yaoundé-Boumnyebel (90 km);

Section 2: Boumnyebel-Pouma (38 km);

Section 3: Pouma-Edea (48 km);

Section 4: Edéa-Douala (66 km).

Each section presents a particular geometry and shows specific features of road insecurity. The geometrical analysis highlights the vertical alignment and

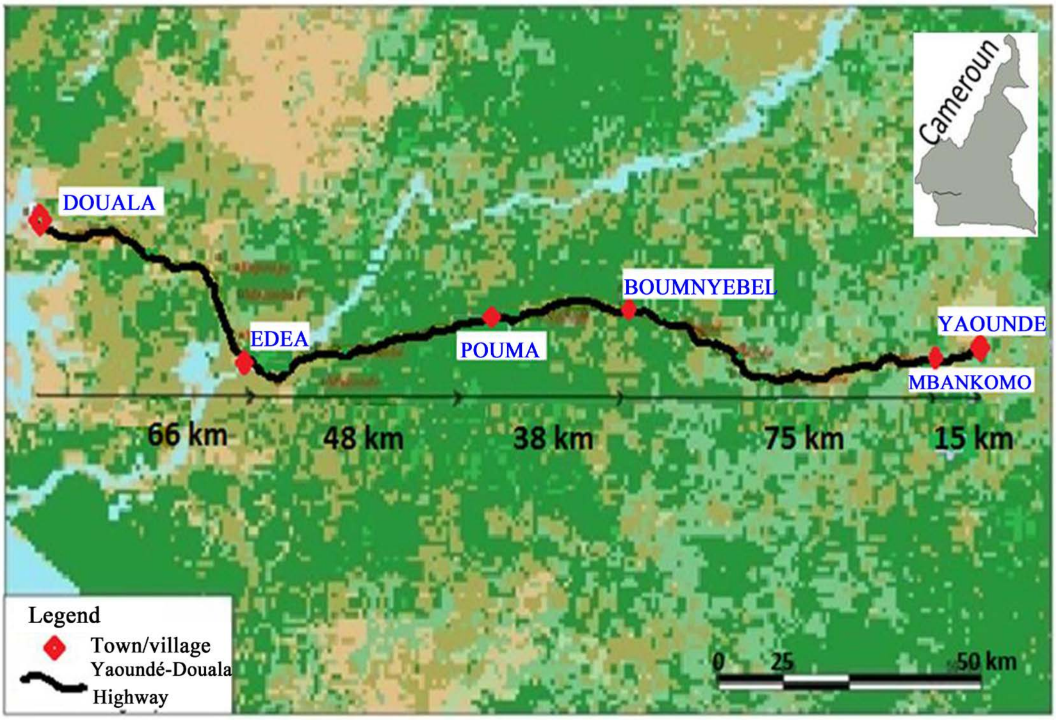

Figure 1. Yaoundé-Douala highway. Source: Association "Recherche-Santé-Développement" and INSERM.

cross-section, and horizontal alignment as well as the number of lanes. The analysis of road insecurity was measured by the rate of accidents or the rate of road hazards and conflicts covered which include:

- The identification and the location of areas of conflict;
- The assessment and the hierarchical organization of the hazard of conflict [9].

This road was built between 1982 and 1985, it was dimensioned to accommodate 2750 vehicles per day, but nowadays it receives more than 6000 vehicles per day. The principal design and geometrical features of the studied section are: length (114 km), width of the roadway (7, 40 m), width of the verge (1, 50 m), speed limit (110 km/h), horizontal radius of the (500 m), slope (4%) and coating of the verges: double-layered.

Currently, this section shows a lot of defects such as subsidence, wrenching, potholes, reduced verge and range, lack of marks on the roadway and other road signs. These imperfections are due to the lack or poor maintenance works and thus may lead to road accidents.

For each of the afore-mentioned analysis criterion, an examination of the hazard of conflict zones was preceded in terms of potentiality, severity, visibility and read-through strength. The itinerary method of study therefore requires the identification of all potential non comprehensible areas by drivers for they may be invisible or disconnected from their context and the adjoining networks. These zones are potential risk zones. From the identification of failure points, the method aims at giving an assessment by proposing a conflict or risk hierarchy.

That is why we can describe the results of each analysis separately [10]. Sections 3 and 4 (total length of 114 km + 20 km) are selected as a sample for their heavy traffic and especially the availability of police reports in the existing data in the said sections.

3.2. The Study Variables

From the accident reports, we have identified several causes of accidents which we group into variables for a good exploitation of the data. The measurement of these different variables and their designation in the simulation process is given in the following **Table 1**.

3.3. Collection and Classification of Accidents from Police Reports

Over a period of six years 2006, 2007, 2008, 2009, 2010 and 2011, we have recorded and classified each accident along the section Douala-Pouma from data obtained from the police or constabulary sources, the residents and the Ministry of Transport. The overall objective of this study is to describe accidents along the Yaoundé-Douala highway. During this period, accidents are distributed as follows (see **Table 2** and **Figure 2**).

The approach consisted of: 1) collecting a copy of minutes established by the authorized police units of the cases studied during the years 2006, 200, 2008, 2009, 2010 and 2011, 2) making a descriptive analysis of the accident rate using information collected from the messages, 3) developing a typology of accidents observed, 4) locating and identifying the road sections favorable for accidents, 5) characterizing accident factors.

Table 1. Table of variables, measurement and design.

Variables	Measurement of the variable	Variable designs
Lack of control	1 when the information is significant and 0 in the contrary	causemm
Driver carelessness	1 when the information is significant and 0 in the contrary	causeimp
Bad parking	1 when the information is significant and 0 in the contrary	casemst
Brake failure	1 when the information is significant and 0 in the contrary	causup
Dangerous maneuvering	1 when the information is significant and 0 in the contrary	causemda
Mechanical failure	1 when the information is significant and 0 in the contrary	causem
Driver inattention	1 when the information is significant and 0 in the contrary	causeina
Wheel bursting	1 when the information is significant and 0 in the contrary	causecl
Excessive speed	1 when the information is significant and 0 in the contrary	causevit
Bad overtaking	1 when the information is significant and 0 in the contrary	causemde

Table 2. Year of accident.

Year	Staff	Percentage
2006	67	7.4
2007	135	14.9
2008	180	19.9
2009	251	27.7
2010	90	9.9
2011	183	20.2
Total	906	100.0

Copy of police reports and messages.

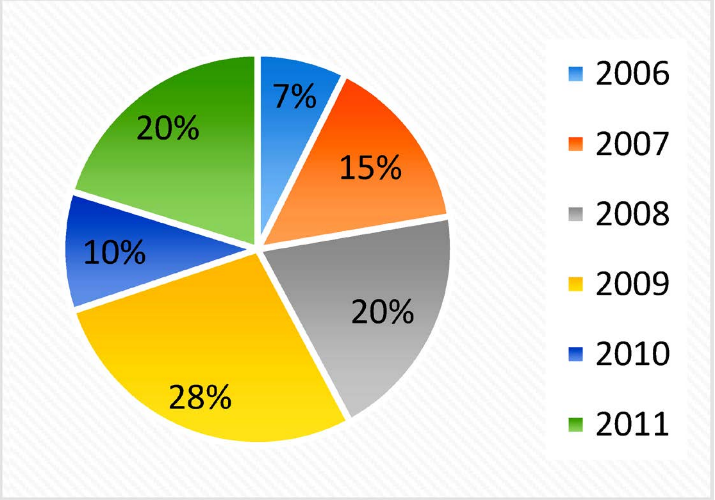

Figure 2. Year of accident.

All the minutes and messages of road accidents along the road sample as well as those of the nearby secondary roads, available at the mobile police unit of Edéa and at the traffic office of the second police region of Cameroon were systematically photocopied. The images were processed by computer and printed.

However, only minutes and messages of accidents along the Pouma-Douala section were used in this study.

3.4. Treatment of Accident Reports

A grid of relevant data from police reports has been implemented from an adaptation of road traffic injury analysis bulletin used in France. A grid was filled for all the police reports of the considered section. A quality control consisted of the cross validation of the pre-filled grid. This process helped to ensure concordance between the information on grids and those on the corresponding minutes and messages.

The encoded information was entered into a designed database and analyzed using SPSS software (SPSS version 11.0).

4. Results and Discussion

From the correlation matrix (Table 3), it appears that there is no strong correlation between the variables in the analysis. Moreover, from the matrix of components after rotation (Table 4) and the table of total variance explained (Table 5), it appears that 5 axes explain nearly 83% of the information provided by all the variables on the occurrence of road accidents. From this result it can be seen that there is a high correlation (correlation coefficient of 0.914) between the factor axis and the driver inattention variable (causina). As a result, this axis is carried by the variable "driver inattention" which explains the accident phenomenon at nearly 23.424%. The second factorial axis and the variable lack of control (causemm) are highly correlated with each other. This axis is carried by the variable "lack of control" which explains the accident phenomenon at nearly 18.517%. The third factorial axis and the excessive speed variable (causevit) have a correlation coefficient of 0.971. This axis is carried by the variable "excessive speed" and explains the phenomenon of accidents at nearly 15.30%. The fourth factorial axis and the variable bad exceedance (causemde) have a correlation coefficient of 0.972.

Table 3. Correlation matrix.

Cause of accident	Lack of control	Driver carelessness	Bad parking	Brake failure	Dangerous maneuvering	Mechanical failure	Driver inattention	Wheel bursting	Excessive speed	Bad overtaking
Lack of control	1.000	−0.192	−0.106	−0.022	−0.043	−0.065	−0.169	−0.117	−0.121	−0.126
Driver carelessness	−0.192	1.000	−0.138	−0.029	−0.055	−0.084	−0.219	−0.152	−0.183	−0.177
Bad parking	−0.106	−0.138	1.000	−0.016	−0.031	−0.046	−0.121	−0.084	−0.088	−0.098
Brake failure	−0.022	−0.029	−0.016	1.000	−0.006	−0.010	−0.025	−0.018	−0.021	−0.020
Dangerous maneuvering	−0.043	−0.055	−0.031	−0.006	1.000	−0.019	−0.049	−0.034	−0.041	−0.039
Mechanical failure	−0.065	−0.084	−0.046	−0.010	−0.019	1.000	−0.074	−0.051	−0.062	−0.060
Driver inattention	−0.169	− 0.219	−0.121	−0.025	−0.049	−0.074	1.000	−0.134	−0.142	−0.117
Wheel bursting	−0.117	−0.152	−0.084	−0.018	−0.034	−0.051	−0.134	1.000	−0.099	−0.108
Excessive speed	−0.121	−0.183	−0.088	−0.021	−0.041	−0.062	−0.142	−0.099	1.000	−0.108
Bad overtaking	−0.126	−0.177	−0.098	−0.020	−0.039	−0.060	−0.117	−0.108	−0.108	1.000
Lack of control		0.000	0.001	0.252	0.100	0.052	0.000	0.000	0.000	0.000
Driver carelessness	0.000		0.000	0.193	0.048	0.006	0.000	0.000	0.000	0.000
Bad parking	0.001	0.000		0.316	0.179	0.081	0.000	0.006	0.004	0.002
Brake failure	0.252	0.193	0.316		0.424	0.385	0.224	0.299	0.263	0.270
Dangerous maneuvering	0.100	0.048	0.179	0.424		0.287	0.072	0.155	0.111	0.119
Mechanical failure	0.025	0.006	0.081	0.385	0.287		0.013	0.061	0.032	0.036
Driver inattention	0.000	0.000	0.000	0.224	0.072	0.013		0.000	0.000	0.000
Wheel bursting	0.000	0.000	0.006	0.299	0.155	0.061	0.000		0.001	0.001
Excessive speed	0.000	0.000	0.004	0.263	0.111	0.032	0.000	0.001		0.001
Bad overtaking	0.000	0.000	0.002	0.270	0.119	0.036	0.000	0.001	0.001	

Table 4. Component matrix after rotation[a].

Causes of accidents	Non-standardized					Resized				
	Component					Component				
	1	2	3	4	5	1	2	3	4	5
Lack of control	−0.030	0.324	−0.031	−0.032	−0.031	−0.089	0.967	−0.092	−0.094	−0.091
Driver carelessness	−0.236	−0.156	−0.135	−0.123	−0.210	−0.589	−0.389	−0.338	−0.306	−0.525
Bad parking	−0.006	−0.009	−0.003	−0.007	0.075	−0.024	−0.035	−0.011	−0.029	0.293
Brake failure	0.000	0.000	0.000	0.000	0.001	−0.001	0.001	0.002	0.003	0.020
Dangerous maneuvering	0.000	0.000	0.000	0.001	0.005	−0.002	0.002	0.003	0.005	0.042
Mechanical failure	−0.001	0.000	0.000	0.001	0.012	−0.004	0.002	0.003	0.007	0.076
Driver inattention	0.336	−0.062	−0.054	−0.047	−0.102	0.914	−0.170	−0.147	−0.128	−0.277
Wheel bursting	−0.014	0−.046	−0.052	−0.063	0.227	−0.051	−0.163	−0.186	−0.225	0.814
Excessive speed	−0.022	0−.027	0.314	−0.026	−0.014	−0.068	−0.085	0.971	−0.081	−0.043
Bad overtaking	−0.017	−0.027	−0.025	0.306	−0.002	−0.054	−0.085	−0.080	0.972	−0.006

Extraction method: Principal component analysis. Method of rotation: varimax with Kaiser normalization. a. The rotation converged in eight iterations.

Table 5. Total variance explained.

Component		Initial Eigenvalues[a]			Extraction Sums of squares of selected factors			Sum of squares of factors used for rotatio		
		Total	% variance	cumulated %	Total	% variance	cumulated %	Total	% variance	cumulated %
Non-standardized	1	0.187	23.424	23.424	0.187	23.424	23.424	0.171	21.395	21.395
	2	0.148	18.517	41.941	0.148	18.517	41.941	0.137	17.187	38.582
	3	0.122	15.306	57.248	0.122	15.306	57.248	0.124	15.542	54.123
	4	0.112	14.052	71.3	0.112	14.052	71.3	0.117	14.62	68.743
	5	0.093	11.623	82.922	0.093	11.623	82.922	0.113	14.179	82.922
	6	0.075	9.398	92.32						
	7	0.033	4.116	96.436						
	8	0.016	2.025	98.461						
	9	0.009	1.14	99.601						
	10	0.003	0.399	100						
Resized	1	0.187	23.424	23.424	1.237	12.368	12.368	1.201	12.014	12.014
	2	0.148	18.517	41.941	1.166	11.66	24.028	1.157	11.573	23.587
	3	0.122	15.306	57.248	1.122	11.219	35.247	1.129	11.292	34.879
	4	0.112	14.052	71.3	1.105	11.045	46.292	1.121	11.214	46.092
	5	0.093	11.623	82.922	1.099	10.987	57.279	1.119	11.186	57.279
	6	0.075	9.398	92.32						
	7	0.033	4.116	96.436						
	8	0.016	2.025	98.461						
	9	0.009	1.14	99.601						
	10	0.003	0.399	100						

This axis is carried by the variable “bad overshoot”. It explains nearly 14.052% of the accident phenomenon. Finally, the fifth axis designated by wheel bursting explains almost 11.623% of the accident phenomenon. This axis is carried by the variable “wheel bursting” (causecl) with which it has a high correlation (correlation coefficient of 0.814).

The correspondence factorial analysis allowed us to build a typology of accidents, thus constituting profiles. Without describing the causes of accidents, these profiles highlight the multi-causality of accidents on Cameroonian roads. Finally, the axes retained are: driver inattention, lack of control, excessive speed, poor passing and wheel bursting. These axes represent the main causes of road accidents in our sample (see Figure 3 and Table 5). The graph below illustrates their positioning. The points furthest away from the axes are those that have a high correlation with them.

We have thus proceeded to the elaboration of accident profiles on our line of study. These results reflect the national and indeed international trend in road accident causality studies and even their categorisation. These results are similar to those obtained by the psychologist Robert Ngueutsa [4] and BPA [11]. In Ngueutsa’s study on the explanation of road accidents according to causes and analysts in Cameroon, he notes that speeding, dangerous overtaking and wheel bursts are ranked among the most important causes of road accidents. Furthermore, the study conducted by the BPA notes that lack of control and driver inattention are among the three predominant types of accidents on Swiss roads.

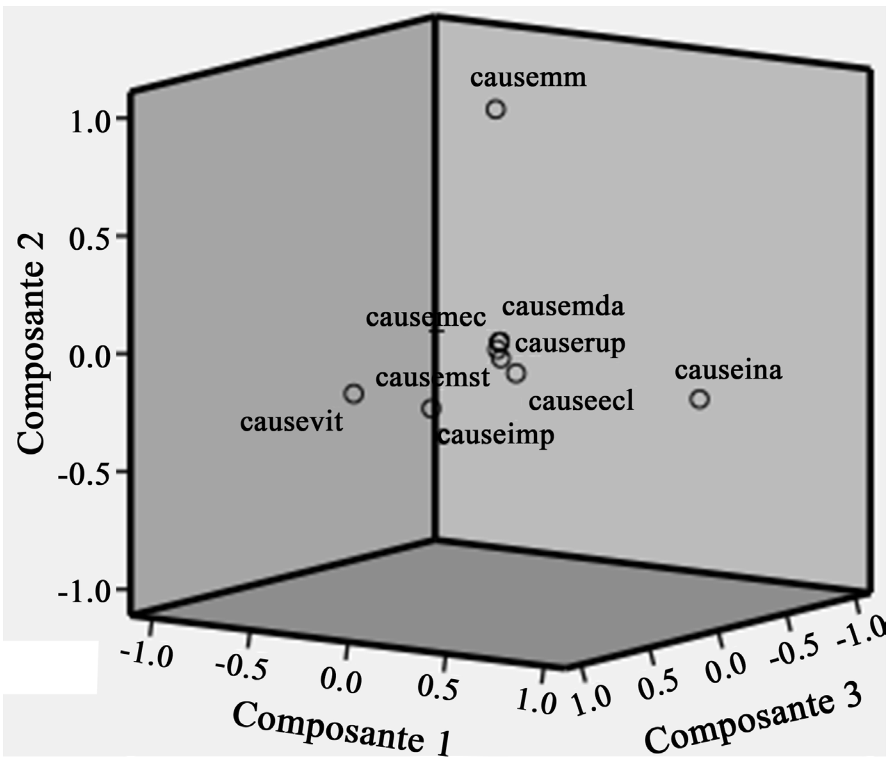

Figure 3. Diagram of components in space after rotation.

5. Conclusions

In this study, correspondence factor analysis is used to classify accidents according to their profile using the reports drawn up by the police forces. In the period from 2006 to 2011, 906 accidents were recorded. The objective here is not to analyse accidents according to their production but to be able to categorise them while retaining as much information as possible from the set of variables.

Although factor analysis does not make it possible to describe the causes of accidents, it does make it possible to develop an overall policy which, if accidents are not eliminated, would make it possible to reduce them or to control their occurrence in cases of force majeure. This policy provides guidance on certain groups of accidents or individuals that can range from awareness to enforcement, thereby reducing the number of accidents and fatalities on our roads.

Accident data sources can be used to establish the presence or absence of a number of factors that can modify the risk of an accident. A description is never an explanation, and the decision-maker is interested in the role of the factor under consideration in the accident, not whether it is present or absent. Therefore, it is necessary to be able to use other elements to produce useful information and to be able to move from describing to attempting to explain the mechanisms and the assessment of risk factors. It is becoming necessary to apply to accidents the methods used in all scientific approaches based on the analysis of epidemiological data if we want to control the phenomenon of accidents in our environment, although the availability and quality of the reports is a brake on this.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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