Use of child restraint systems

Compact accident research

Unfallforschung der Versicherer

GDV

Contents

Introduction

Many people these days are highly dependent on cars to get them where they want to be when they want to be there, and it goes without saying that they also want to take their children with them. The safety features of vehicles are designed for adult occupants. Consequently, special safety equipment has to be used for children (child restraint systems – CRSs).

The protection offered by child seats has improved constantly since they became mandatory in 1993. Although a wide range of different models are available, it can reasonably be said that even the simplest and cheapest seats offer adequate protection in theory. The main problem in connection with child seats is misuse. Studies have repeatedly shown that around two-thirds of all child seats are used incorrectly [1–5], which can considerably reduce or even nullify the protection they provide.

The misuse of child seats and the associated problems should therefore be continually examined. Since the last major field study conducted in Germany and elsewhere in Europe [5], circumstances have fundamentally changed. The ISOFIX system is now a statutory requirement for affixing the child seat to the vehicle, and new legislation on the approval of child seats (ECE-R 129) has come into force.

Consequently, the purpose and goal of this study of misuse is both to give a current picture of the use of child seats and to ascertain whether the action taken in the past to improve child safety in cars has been effective. In terms of its scope, this study sets a new benchmark. With over 1,000 cases examined, it is significantly more comprehensive than all previous field studies on this issue in Germany.

Description of the field research on misuse

This research project examined the frequency and seriousness of misuse in reality. In addition, brief interviews were conducted with the drivers of the cars. Depending on the willingness of the person interviewed, an in-depth telephone interview was conducted as well.

Research tools

In order to learn as much as possible about all the interesting aspects of misuse, data was collected on the frequency, seriousness, etc. of misuse as well as on the underlying knowledge, attitudes and capabilities of the users. Two research tools were developed to record forms of misuse, the motives underlying them and relevant contextual conditions in the field. Both of these tools – an observation sheet and a questionnaire for the subsequent survey – are based on the hypotheses developed in the course of systematizing the causes of misuse in previous studies.

Observation sheet

The observations, which were recorded at various locations (e.g. supermarket, leisure facilities, kindergarten, school), focused on misuse. The observation sheet documented the weather conditions and location and had a total of four sections: information on the vehicle and occupants, information on the person interviewed, information on the child, child restraint system (CRS) and misuse and, lastly, questions about the misuse identified.

Forms of misuse

Any deviation from the intended way of using a child restraint system that could reduce the level of protection offered is interpreted here as misuse or incorrect use. The check list (further) developed in the previous projects was used to record the misuse observed. The seriousness of the misuse (minor, moderate, serious) was rated a priori only for selected forms of misuse; all others were rated subsequently.

The code book has three sections. The possible types of error for Group 0/0+ seats are listed in the first section, the error types for Group 1 seats in the second section and the error types for Group 2/3 seats in the third section. This also applies to the seat models approved after ECE-R 129.

Questionnaire

The subsequent survey once misuse had been identified for all the children in the vehicle was designed to record contextual conditions, the reasons why people did what they did and action-related elements of knowledge. The questionnaire for the subsequent survey included questions about the purchase and fitting of the child seat and about securing the child in the child seat.

The observation and survey tools were subjected to preliminary tests in advance of the field research in order to check them against the criteria of consistency, comprehensibility and acceptance. Based on experience in previous studies, the observation and survey components were separated. As a result of the time it took the subjects to complete the survey (approx. 30 minutes) in previous studies, there were considerable problems getting them to accept it, and this cast doubt on whether the research could be completed. Consequently, a subsequent telephone survey very soon afterwards (i.e. two to three days later) was suggested to the subjects as an alternative to an on-the-spot survey.

Conducting the field research

The field study was started following the successful conclusion of the preliminary tests at the end of June 2016 and completed in June 2017. The data collected was evenly distributed throughout this period (figure 1).

Description of the field research on misuse

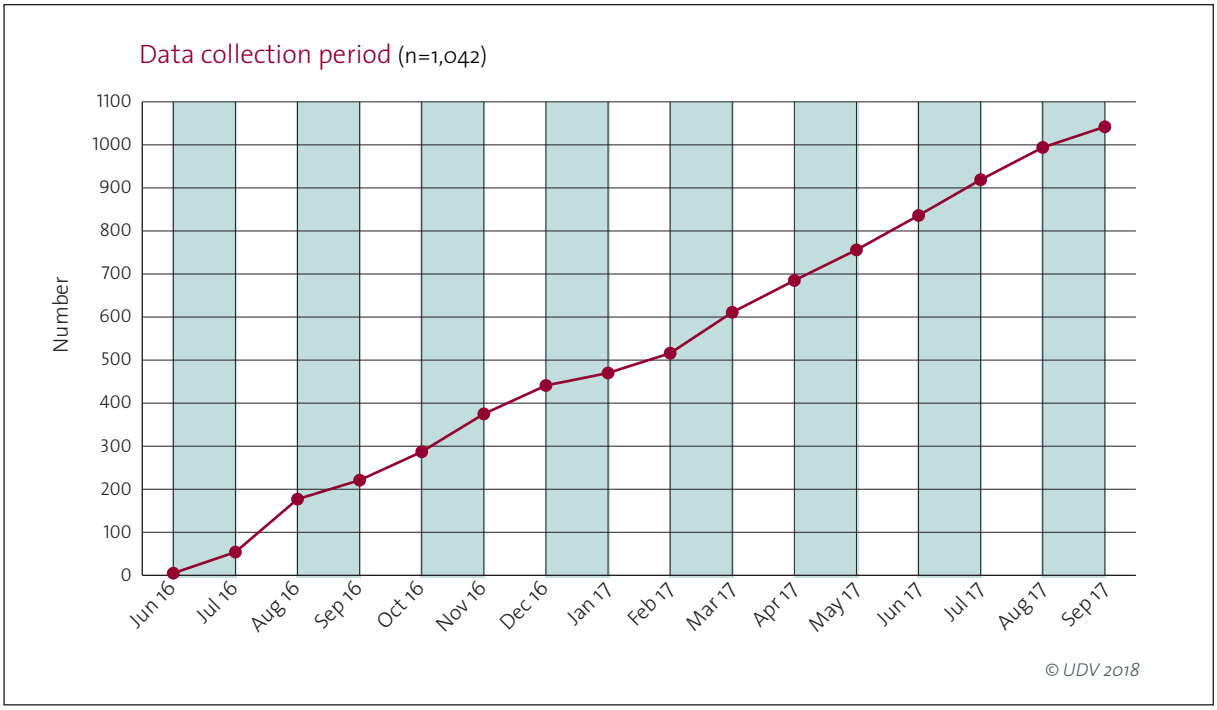

Figure 1: Research period

The securing or otherwise of a total of 1,076 children in cars was recorded. 1,042 of them were secured in a child seat, while 34 were not secured. The children were most often in Group 2/3 seats (n=472), followed by Group 1 seats (n=372) and Group 0/0+ seats (n=198). The study was conducted at selected locations in the greater Berlin and Munich areas. Figure 2 shows an overview of the survey locations. These included both urban areas and locations in the commuter belt as well as cities some distance away (e.g. Leipzig, Potsdam, Augsburg and Rosenheim). The selection of different locations ensured that different journey purposes were taken into account in the study (shopping, kindergarten and school runs, leisure).

The initial criterion for selecting the subjects was that people stopped at these locations at a given time and were driving with children aged up to 12 years old. The aim was to take a random sample and include all child restraint system types in the study. The drivers were generally approached by the observers, who then explained to them what the study was about. When the drivers declared that they were willing to take part, one of the observers collected the general information required by the observation sheet. At the same time, the second observer checked how well the children were secured in the child restraint system and how well the seat was secured to the vehicle. They then either conducted the survey on the spot for all the children in the vehicle or arranged a telephone appointment for the survey in the next few days. An average of 15 to 20 minutes per vehicle was required when the survey was conducted on the spot. This varied depending on the number of children secured in the vehicle.

Compared to previous studies, there were a significantly larger number of cases in the field research (figure 3). The large data set of 1,042 cases also permits a detailed analysis for specific lines of questioning, allowing reliable results to be obtained.

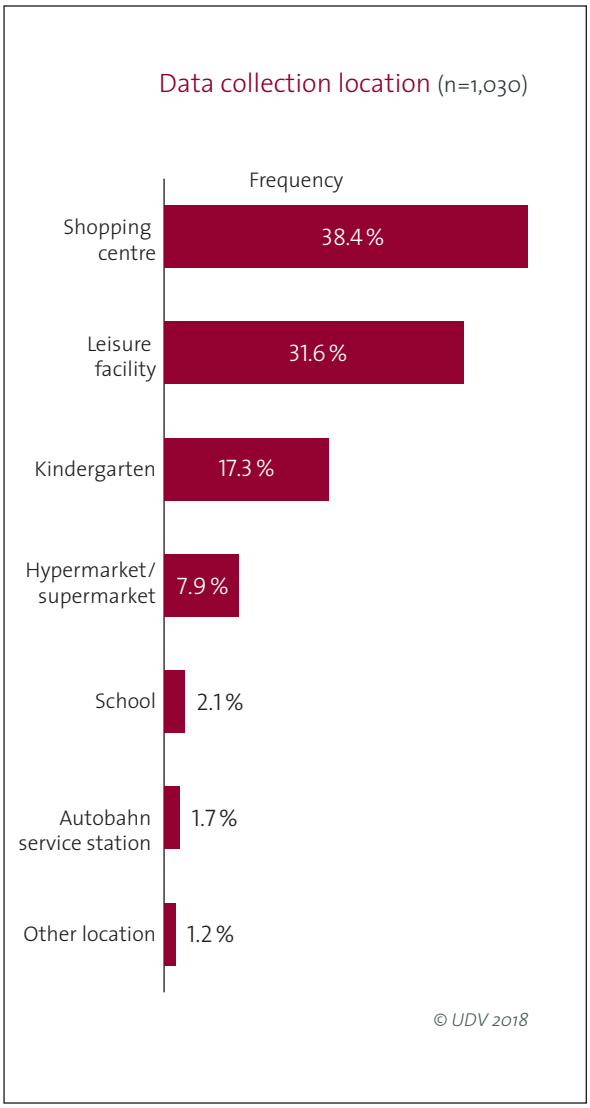

Figure 2: Location in the study

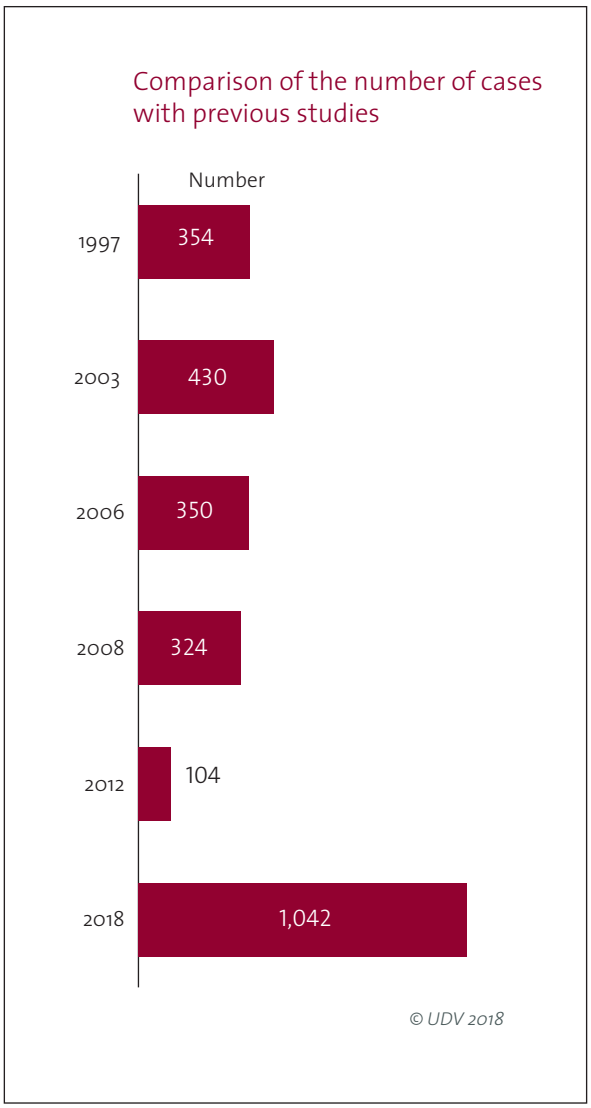

Figure 3: Comparison of the number of cases with previous studies [1–5]

Results of the field research

Description of the sample

The sample is described in terms of the children studied, the vehicles involved, the vehicle occupants and the child seats used.

There were two to six people in each vehicle. In almost two-thirds of the vehicles in the study, there were two or three people. There were one to four children under 12 years of age (i.e. children who are supposed to be secured in a child seat) in the vehicles studied. In over 80 percent of the vehicles, however, there were no more than two children.

47.3 percent of the 1,042 children were female and 52.7 male. The children ranged in age from one month to 12 years old. Figure 4 shows the age distribution of the children.

As mentioned above, an approach was generally made to the drivers of the vehicles. 58 percent of the interview partners were the mother of the child/children, 33.7 percent were the father, 5.4 percent were a grandparent, and 2.9 percent were another relation or friend (see figure 5 on the next page).

Child restraint system Groups 2/3 and 1 were most common with 45.3 percent and 35.7 percent, respectively; Group 0/0+ accounted for 19 percent. 90.4 percent of the child restraint systems used were compliant with the ECE 44.04 standard, and 7.9 percent with the ECE 44.03 standard. Only 0.3 percent were compliant with the outdated ECE 44.02 standard, and 1.4 percent with the new ECE-R 129 standard. Most of the child restraint systems (80 percent) were fastened with a three-point automatic seat belt. An ISOFIX system was used in 20 percent of the cases. In only four cases was an integrated child restraint system used.

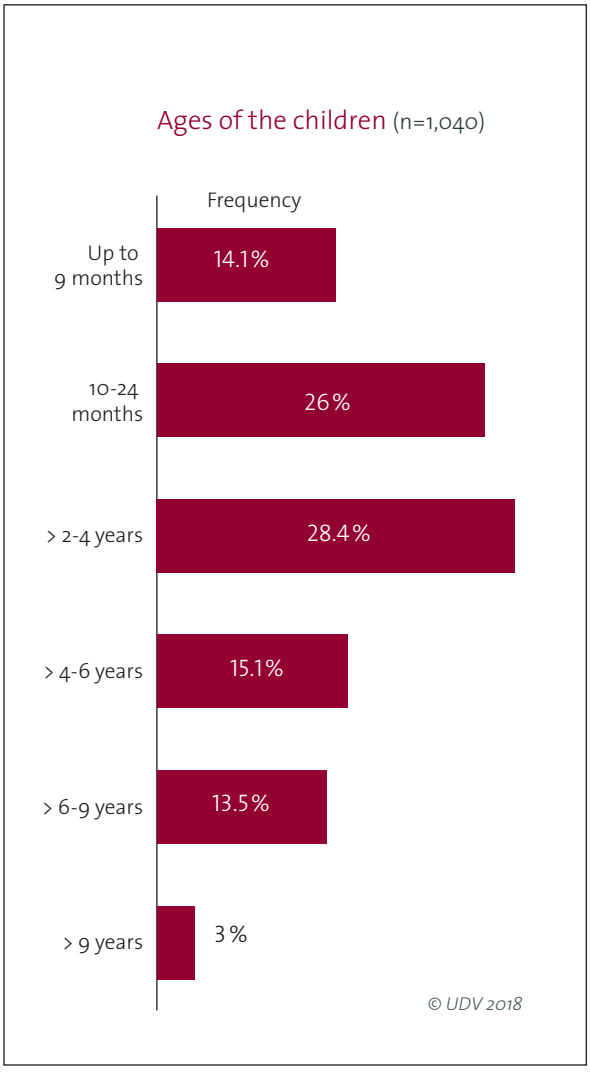

Figure 4: Age distribution of the children under 12 years of age

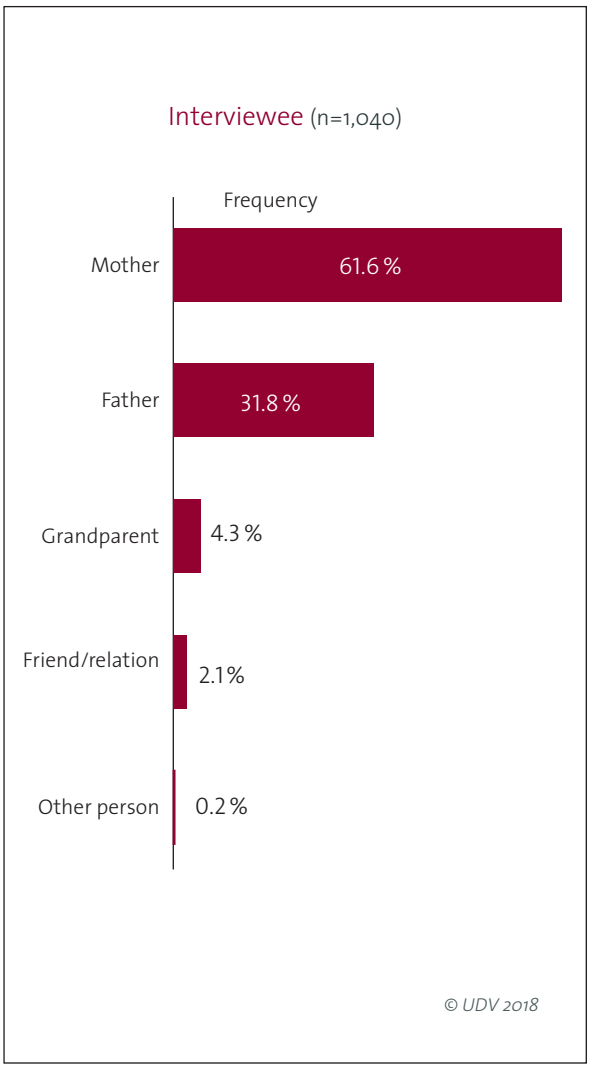

Figure 5: Interviewees

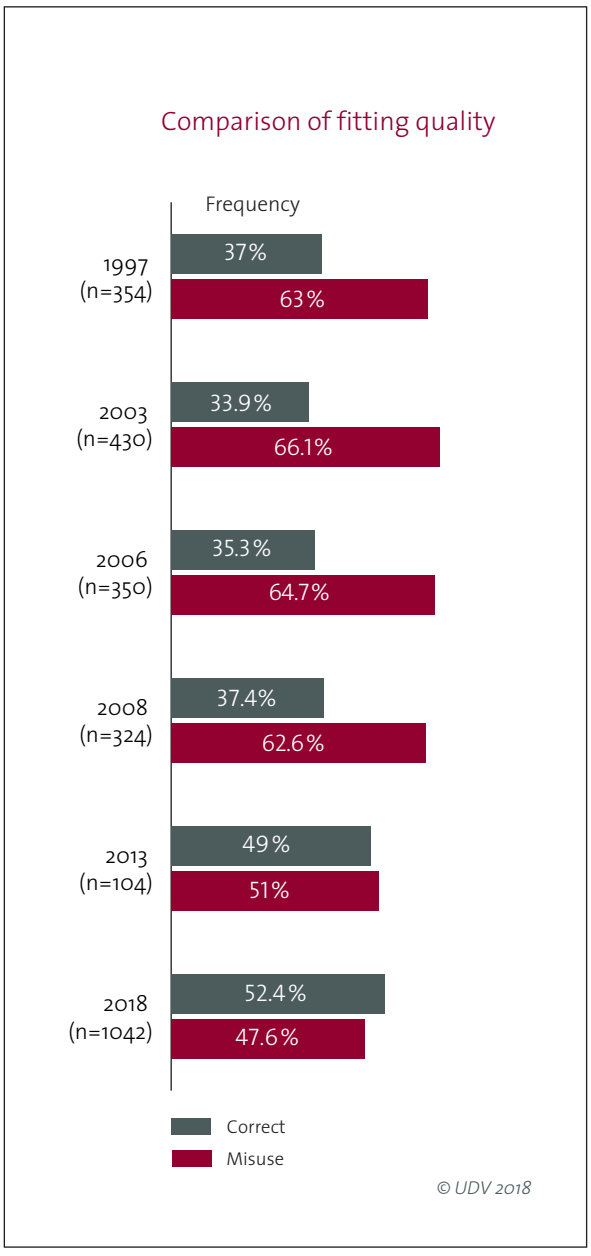

Figure 6: Comparison of the misuse rate with that of previous studies [1–5]

Results of the misuse observations

General investigation of misuse

52.4 percent of the total of 1,042 children were correctly secured, and 47.6 percent were incorrectly secured. The misuse rate is thus under 50 percent for the first time in this kind of study (figure 6). The misuse rate for child seats has dropped significantly.

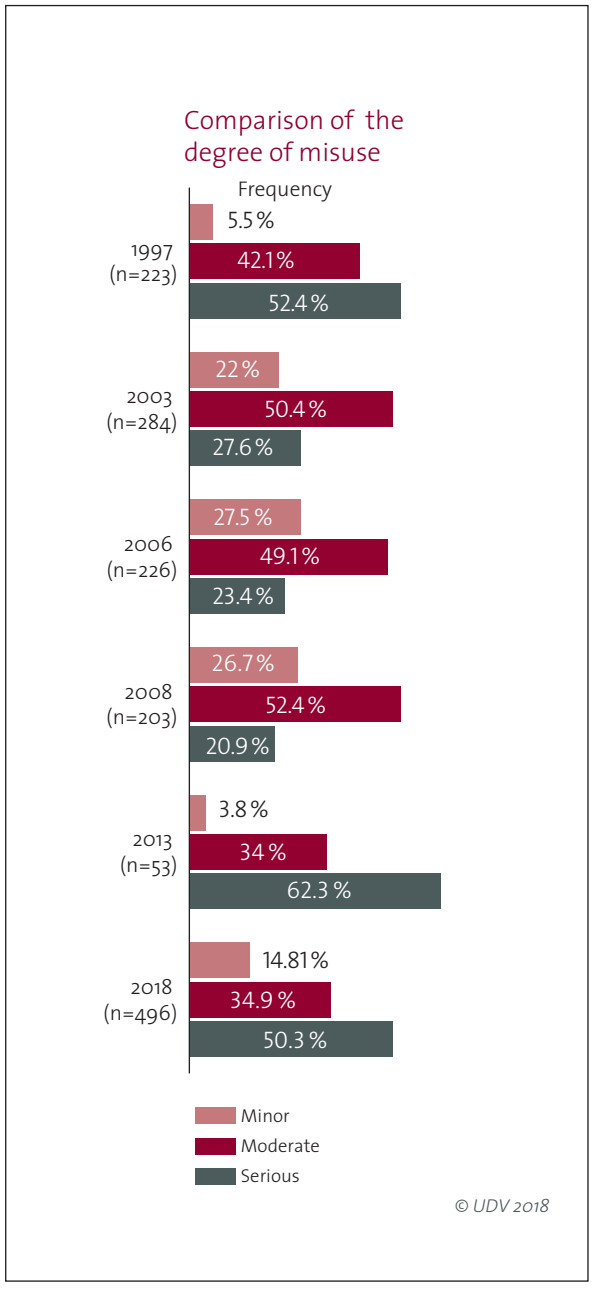

Figure 7: Comparison of the degree of misuse with that of previous studies [1–5]

Half of all the observed misuse was rated serious, 35 percent moderate and 15 percent minor. Compared to previous studies, the frequency of misuse is significantly lower overall, but the seriousness of the misuse identified is higher (figure 7). Progressive developments in modern child restraint systems are ensuring that some widespread, long-standing forms of misuse can be avoided really quite easily. When misuse does occur, however, it is comparatively serious.

When the misuse rate is broken down across the different groups of child restraint systems, it varies greatly. Misuse occurs in Groups 0/0+ and 1 significantly more frequently than in Group 2/3 (figure 8) ($p=0.004$). The main reason for this is that it is significantly easier to secure a child in a Group 2/3 seat, since in this case the child and child seat are secured together by means of the seat belt. In the other two child restraint system groups, the child seat generally has its own belt system for securing the child in the seat, and the seat is fitted in the vehicle separately.

Various factors are examined below that may contribute to misuse. For example, bad weather with rain significantly increases the misuse rate (figure 9) ($p<0.001$). It seems likely that, when it is raining, people secure their children very quickly and imprecisely. Consequently, they are not secured as well.

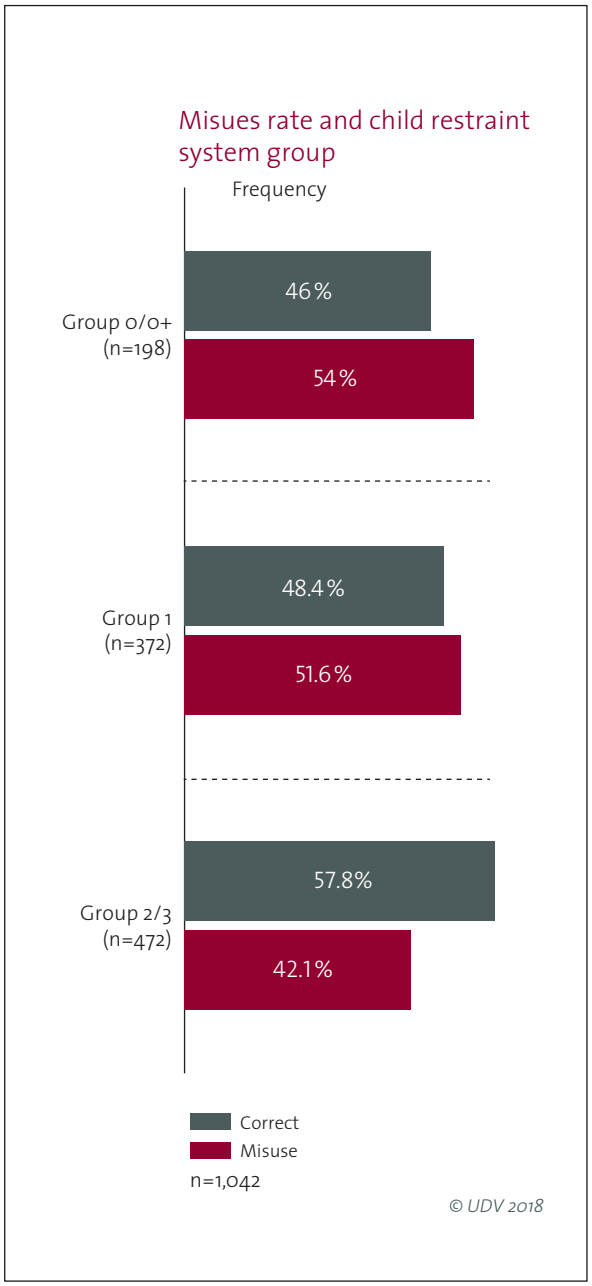

Figure 8: Misuse rate depending on child restraint system group

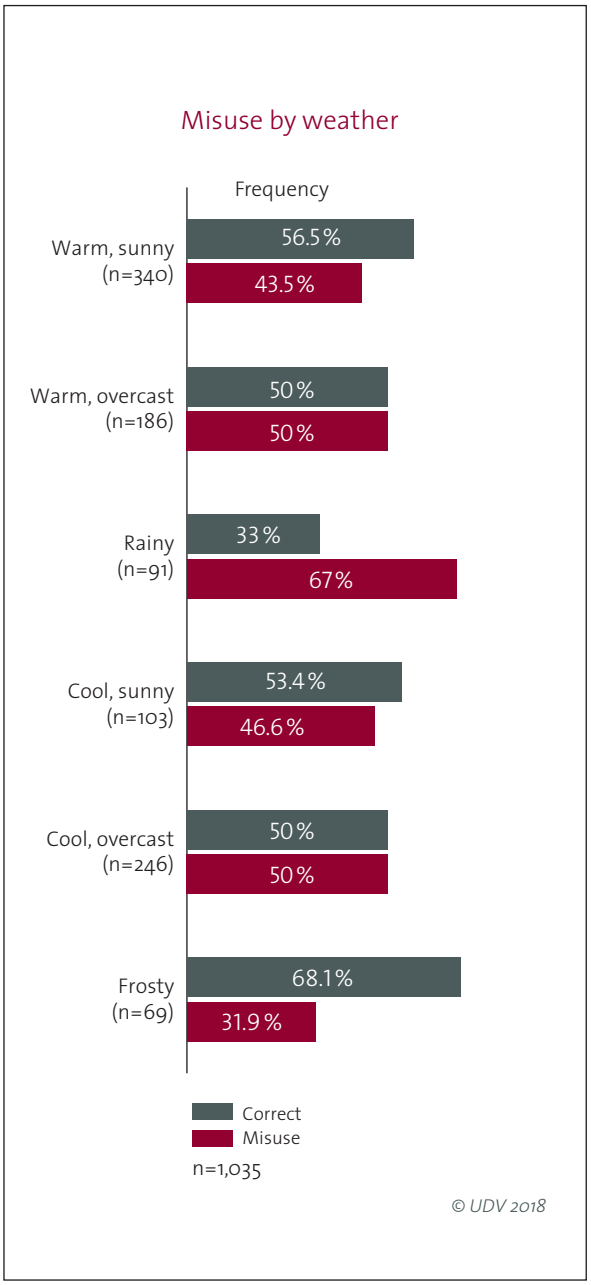

Figure 9: Misuse depending on weather

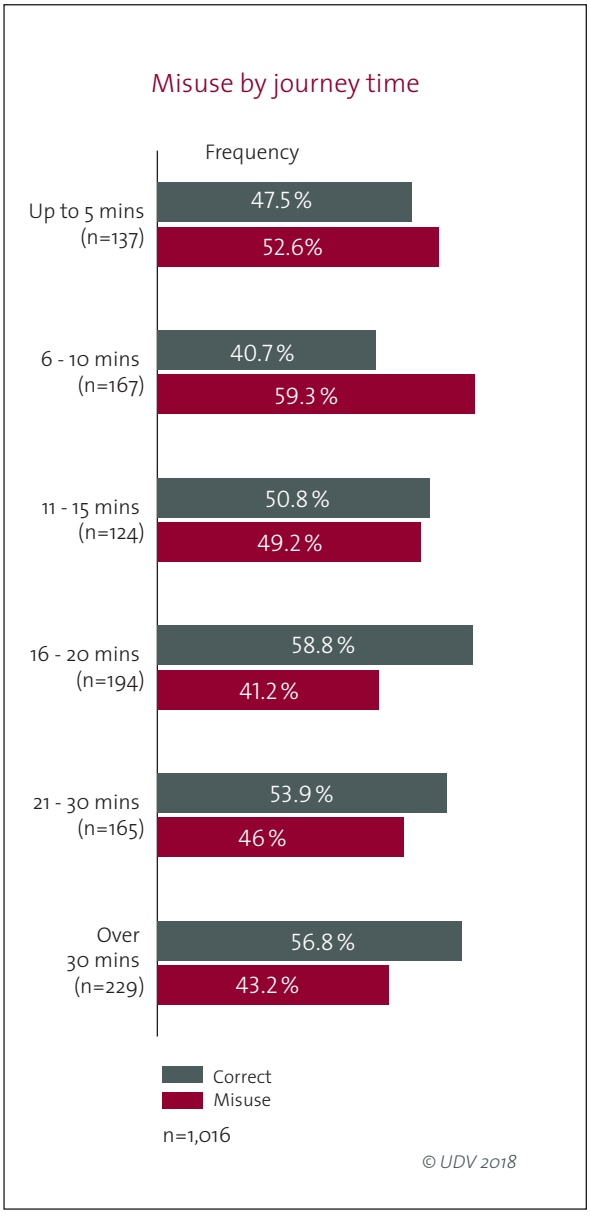

Figure 10: Misuse depending on journey duration

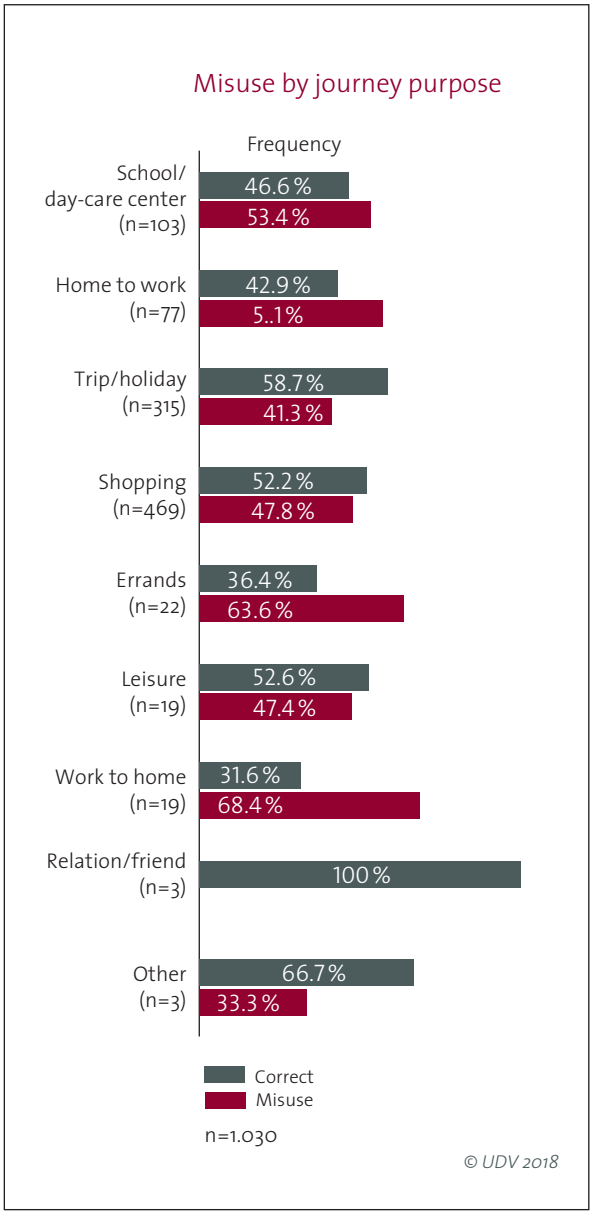

Figure 11: Misuse depending on the purpose of the journey

The journey duration also significantly affected the misuse rate. As found in previous studies, significantly more errors were made for short journeys of up to 10 minutes than for longer journeys (figure 10) (p=0.013). There is evidently still a widely held assumption that securing a child properly is less important for short journeys.

A significant relationship was also found between the purpose of the journey and the frequency of misuse. Journeys that tend to involve a lot of rushing about and in which time appears to be short are also associated with a higher rate of misuse (figure 11) (p=0.016). This is particularly clear for journeys to and from school or kindergarten and for errand-related journeys.

There are significantly more child restraint systems affixed to the vehicle by means of ISOFIX in this study than previous studies. This trend has a very direct impact on the frequency of misuse. As can be seen in figure 12, there is very significantly less misuse in connection with ISOFIX seats than with child seats secured by means of a three-point seat belt (p=0.000). This illustrates the positive impact of a technical standard with which vehicles and child restraint systems have increasingly complied in recent years.

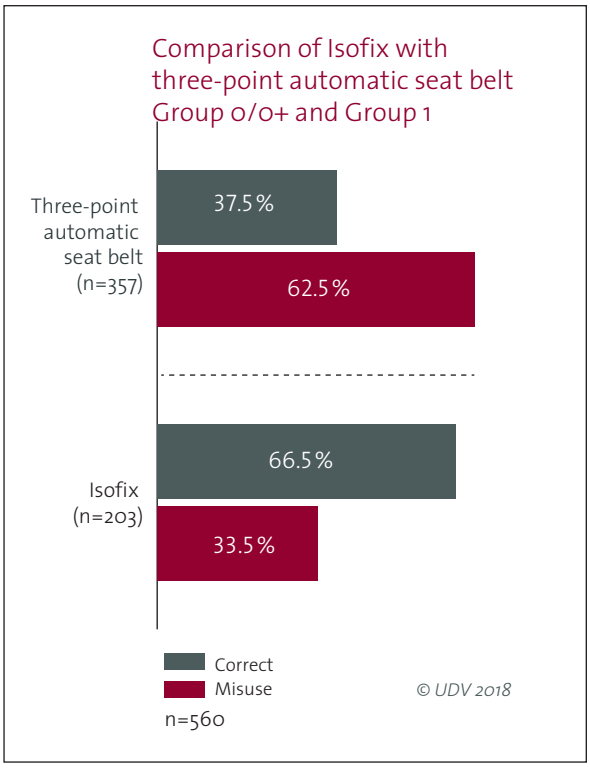

Figure 12: Comparison of ISOFIX and three-point automatic seat belt in Groups 0/0+ and 1

A highly significant relationship was also found between the misuse rate and citizenship of the interviewee (generally the person securing the child) (figure 13). The misuse rate was significantly higher among those who were not German citizens (p=0.000). People from south-eastern Europe, Turkey and Arab countries featured particularly strongly in this group. The interviews conducted repeatedly showed that the effect described has particularly cultural causes. It is thus all the more necessary to continue to develop and implement ways of addressing people of these other nationalities and convincing them of the importance of securing children in vehicles properly.

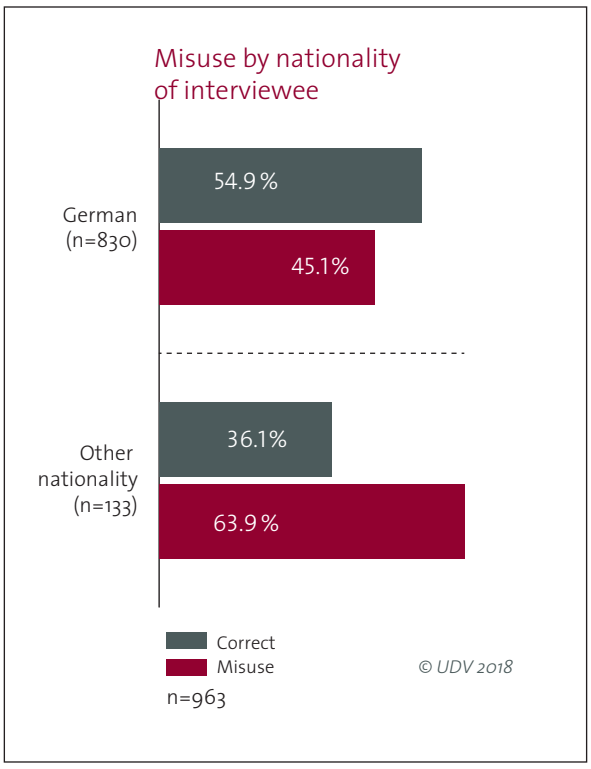

Figure 13: Misuse rate by nationality of the interviewee

Errors fitting the child restraint system

Fitting errors are examined in some depth below. Fitting errors are errors that occur when fitting the child seat in the vehicle. These errors are completely different from securing the child in the seat.

Fitting errors with Group 0/0+ seats are dominated by errors in connection with the car's seat belt. These are, in particular, a slack seat belt, failure to use the guides for the seat belt and mixing up the lap and shoulder belts (table 1). Depending on their extent, all three of these er-

rors are classed as serious misuse. Mixing up the shoulder and lap belts essentially means that the child and child seat are not secured in the car. The three types of misuse mentioned have two important factors in common. There pose a considerable risk of injury to the children, and they can be effectively avoided if ISOFIX is used.

Table 1: Top five fitting errors in Group 0/0+ (n=145)

Fitting errors in Group 0/0+	Frequency (%)
Seat belt slack	24.8
Belt guide not used	19.3
Lap and shoulder belts mixed up	16.6
Carrying handle incorrectly positioned	9.7
Seat belt twisted	7.6
Other errors	22.1

Failure to disable the passenger airbag when a baby car seat is fitted in the front passenger seat counts as a particularly serious error with Group 0/0+ seats. Although there are numerous warnings about this in the vehicle's interior, and this point is a separate offense in the German catalog of fines (Bkat), the airbag was not disabled in almost 15 percent of the cases in which an infant car seat was fitted in the front passenger seat. This is all the more remarkable due to the fact that disabling an airbag is generally very easy in modern vehicles. Accidents in which the infant car seat is hit by a triggered airbag can cause considerable injuries to the child.

Mixing up the shoulder and lap belts also occurs very frequently, accounting for 16.6 percent of the cases. This happens when the lap belt is fed behind the infant car seat, and the shoulder belt goes over the child at the front. If this error is made and there is a frontal collision, the infant car seat with the child in it is thrown forward unimpeded and – depending on where it is fitted – crashes against the dashboard or the backrest of the front seat. The associated deceleration force is correspondingly high and subjects the child to heavy loads.

To illustrate the consequences of this form of misuse, two sled tests were conducted as part of this study to compare correct and incorrect use of the belt (figure 14).

Figure 14: Comparison of the fitting of the infant car seat. Above: correct use of the belt (test 1). Below: incorrect use of the belt (from above, test 2)

To prevent the dummy from being damaged in the misuse test, the infant car seat was secured in such a way that it could initially be displaced forward unimpeded but was then held back as of a specific point by a retaining strap. A Q1 dummy was used for the tests. This was the size and weight of an average one-year-old child. The tests were conducted with a speed on impact of 50 km/h in accordance with ECE-R 129 (figure 15).

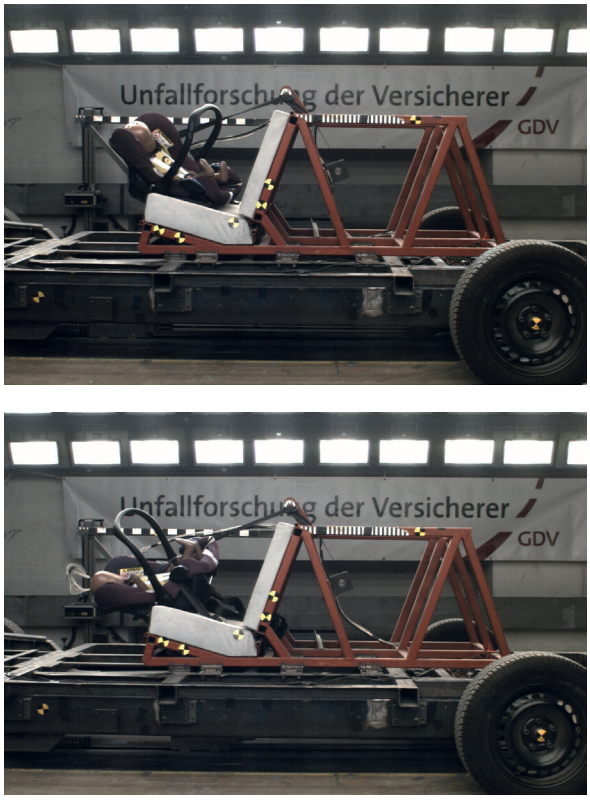

Figure 15: Maximum forward displacement of the infant car seat with correct (above) and incorrect (below) fitting

When the two tests are compared, it can be seen that the infant car seat is displaced forward to a moderate extent in the first test (with correct use of the belt) and is deformed, thus absorbing energy. The biomechanical loads that occur are low and significantly below the statutory limits. In the second test (with incorrect use of the belt), the infant car seat is displaced forward virtually unimpeded. This forward displacement is only stopped by the retaining strap. In a real vehicle, this forward displacement would result in violent impact with the vehicle's interior, and the child would be subjected to very high loads. The misuse represented in this comparison illustrates what huge consequences apparently small errors can have.

There is a very similar picture for fitting errors with Group 1 seats. In this group, too, problems occur, above all, when people use the seat belt incorrectly (table 2). The most common problem is slackness in the seat belt, which was found in almost half of all Group 1 seats examined. Slackness in the seat belt is rated with different degrees of severity depending on its extent. In the great majority of these cases, the slackness in the seat belt was serious (63 percent, compared to 26 percent for moderate slackness and 11 percent for minor slackness). This considerably reduces the protection offered by a child restraint system and can result in serious injuries to the child.

Table 2: Top five fitting errors in Group 1 (n=225)

Fitting errors in Group 1+	Frequency (%)
Slackness in the seat belt	49.3
Seat belt twisted	12.9
Belt guide not used	10.2
Seat belt buckle not or incorrectly used	4.4
Isofix without anti-rotation feature	4.0
Other errors	19.1

This error and the other three errors listed in table 2 are also reliably prevented by ISOFIX. It is noteworthy that the fifth most common error is directly connected to the fitting of Group 1 ISOFIX seats. In 4 percent of all Group 1 seats, the anti-rotation feature (i.e. the top tether) was not used. This error is rated serious in the code book. This illustrates once more that, in spite of how simple it is to use ISOFIX overall, the use of anti-rotation features presents people with problems. It seems there is further room for improvement here.

The picture is not quite as clear for fitting errors with Group 2/3 seats (table 3). Many different errors were observed, each of which occurred only infrequently. Generally speaking, however, there is less to bear in mind when fitting these seats, since the seat is secured in the vehicle together with the child.

Table 3: Top six fitting errors in Group 2/3 (n=35)

Fitting errors in Group 2/3+	Frequency (%)
Blanket (or similar) under child restraint system	11.4
User's own solution	11.4
Interaction problem with headrest (of vehicle)	11.4
Impermissible fitting position	5.7
Child restraint system damaged	5.7
Isofix not engaged on the belt buckle side	5.7
Other errors	48.6

Errors securing the child

The child is secured in the child seat either by means of the child restraint system's own belt system, an impact shield that belongs to the child restraint system or the vehicle's seat belt, which secures both the child restraint system and the child. Errors observed in connection with this are described in this section.

In the case of Group 0/0+ child restraint systems, slackness in the seat's integrated belt system is by far the most common problem. This error accounted for over 90 percent of all errors when securing babies in Group 0/0+ seats. Depending on the extent of this error, the effects in the event of an accident vary. If the belt is so slack that the shoulder belt can slip over the shoulders and the baby can slip under the belt, in the worst-case scenario the baby is essentially not secured and can be ejected from the child restraint system unimpeded. Other kinds of error were only very infrequent.

Slackness in the seat belt was also the most common problem with Group 1 seats, accounting for 90 percent of all errors made securing the child. Here, too, this error is particularly serious when the shoulder belt runs the wrong side of the child's shoulders and thus doesn't restrain the upper body. The upper body folds forward, and the child is only held back by the lower section of the child restraint system belt. The forces to which the abdominal area is subjected are then all the greater, which can lead to very serious injuries.

Slackness in the lap belt was also the most common error made when securing children in Group 2/3 seats (table 4). In addition, a large number of errors were made with the belt path of the vehicle's seat belt. Some are characterized as minor errors in the code book, such as the headrest of the child restraint system being set too high. Other forms of misuse, however, can have severe consequences and are therefore categorized as serious. These include running the shoulder belt under the child's shoulder, for example, so that it can no longer hold back the child's upper body. As described for Group 1 seats, this can also lead to serious abdominal injuries.

Table 4: Errors securing children in Group 2/3 seats by frequency

Securing errors in Group 2/3+	Frequency (%)
Lap belt slack	44.8
Seat belt twisted	11.5
Shoulder belt slack	9.4
Lap belt not inserted in the guide on the buckle side	9.4
Shoulder belt not inserted in the guide on the anchorage side	8.6
Lap belt not inserted in the guide on the anchorage side	4.7
Shoulder belt clamped under arm	2.9
Belt in contact with neck	2.1
Child seat headrest too high	1.8
Shoulder belt inserted in the guide on the buckle side	1.6

Assessments of those securing the children

After the on-the-spot checks, the people securing the children were interviewed. Over 80 percent of them responded in the affirmative to the question, "Do you believe that everything was properly secured?" It is striking, however, that over 70 percent of those who were found to have made errors were also convinced that they had done everything correctly (figure 16).

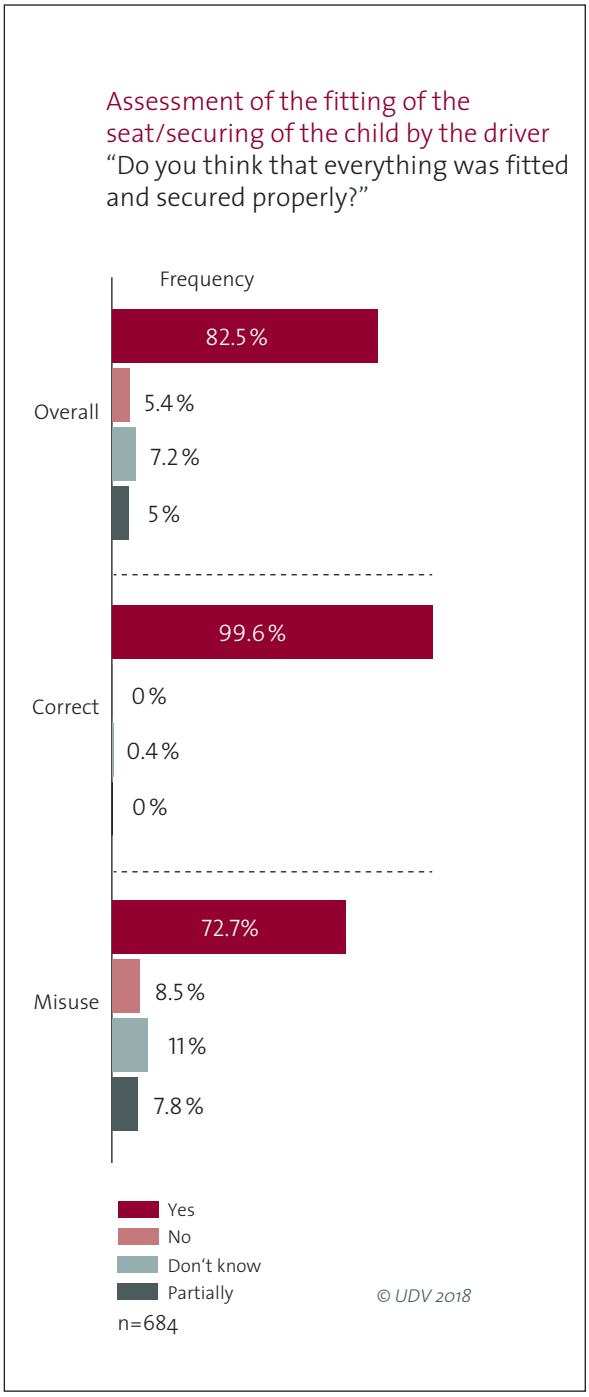

Figure 16: Assessment of how well the child is secured by the driver

Assessments of those securing the children

When the observers identified misuse, the subjects were asked to assess the extent to which this had compromised safety: 26 percent believed there was no reduction in safety, 13 believed there was a slight reduction, while 9 percent and 14 percent believed there was a substantial or severe reduction, respectively. 37 percent could not come up with an assessment and stated that they didn't know. If you examine the assessments given for each of the child restraint system groups, the answers given are largely congruent. As shown in figure 17, a considerable portion of the interviewees were of the opinion that misuse of the child seats would have no consequences of any kind in terms of their protective effect: This subgroup accounted for almost 20 percent of interviewees in cases of serious misuse, over 30 percent in cases of moderate misuse and 40 percent in cases of minor misuse. Only a small number of them gave a realistic assessment of the associated risks.

In reply to the question as to the causes of the misuse identified, the interviewees most often answered that it was due to unconscious negligence (table 5). Further quantitatively significant causes were gaps in knowledge about the correct use of the child restraint systems, insufficient or false information about the correct use of the systems, the shortness of the journey, the desire to improve the comfort of the child, clothing-related misuse, the child being allowed to secure itself and conscious negligence. Points such as technical problems, laborious fitting, etc. played a comparatively minor role.

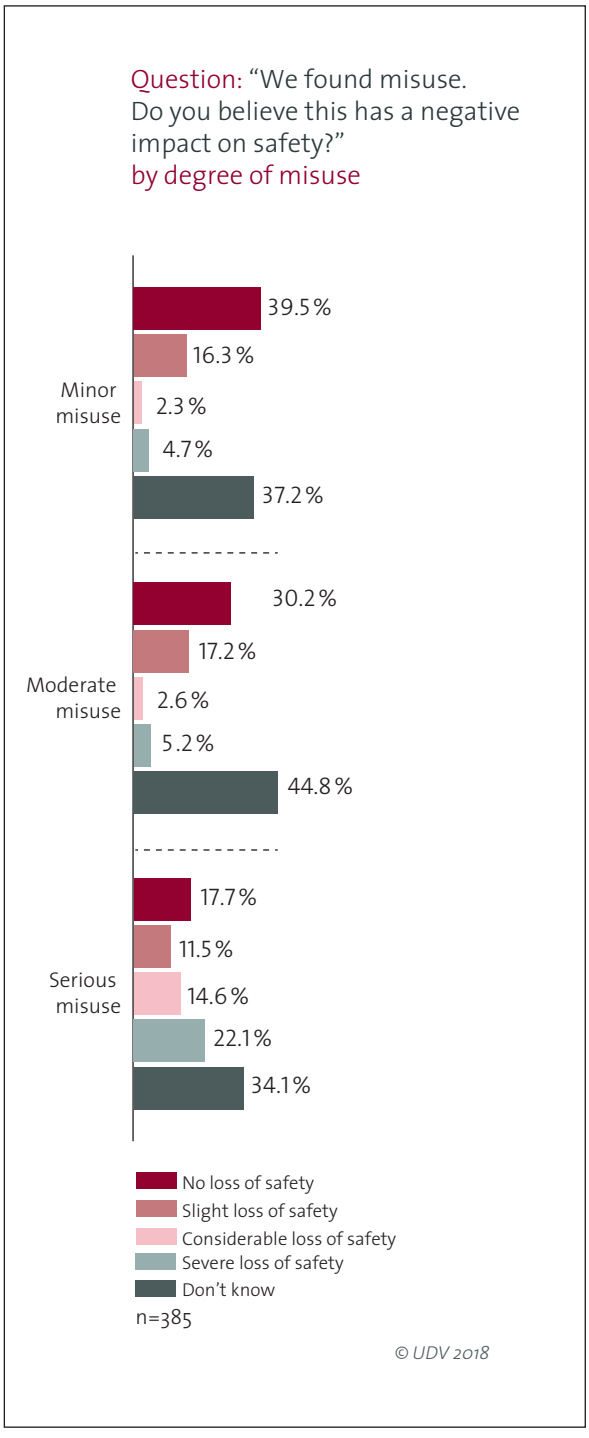

Figure 17: Answer to the question as to the effect of the identified misuse on safety

Table 5: Causes of misuse by frequency (multiple responses possible) n=321

Causes of misuse	Frequency (%)
Unconscious negligence	32.9
Lack of knowledge	10.1
Child secures itself	9.1
Insufficient/false information	6.2
Improvement of the child's comfort	5.9
Short journey	5.5
Time pressure	5.3
Conscious negligence	4.3
Technical	3.5
Clothing related (thick/thin)	3.2
Resistance from the child	3.2
Laborious to fit the seat/secure the child	2.7
Second/other car, switch of vehicle	2.2
Multiple children	1.4
Change of seats	0.3
Other reasons	4.3

Possible measures/ suggested improvements and recommendations

Based on the empirical results of the previous studies referred to above, systematic recommendations and demands have been made to those with key responsibility for the safety of children in cars. A number of these recommendations have been implemented over the years, and they have undoubtedly contributed to the reduction in the misuse rate found in this study. Nevertheless, some recommendations for dealing with the problem of misuse have not, or not yet, been implemented.

Recommendations to manufacturers of child restraint systems and vehicles

As the current study shows, ISOFIX anchorages dramatically reduce the potential for misuse when fitting child restraint systems. The use of ISOFIX must therefore continue to be encouraged.

Although instruction manuals and pictograms are rated positively by a large majority of child restraint system users in terms of their clarity and information content, at the same time many users are still not able to recognize misuse as such. This indicates shortcomings of these instructions in terms of practical relevance, which must therefore be improved. To optimize comprehensibility and clarity, instruction manuals and pictograms must be conceived and designed in such a way as to allow any user to use the child seat correctly.

As of a certain age, children actively engage with their child seat, want to make it (more) comfortable or just work out how it all works. Interference by children is thus a significant source of misuse. To prevent children from interfering with the belt buckle, it should be fitted with a

mechanism that functions as a child lock. It would be conceivable to fit a sensor that would identify such interference and notify the driver.

Problems with belts – particularly slackness – are the most frequent sources of misuse. Systems for preventing slackness in the seat belt and child restraint system harness should therefore be improved and distributed.

The next two recommendations are based not on the empirically obtained data of this field study; they come from systematic observations and experiences of the interviewers on the spot. They therefore shouldn't go unmentioned here.

Interviewees quite frequently reported that they had seen instruction videos on fitting their child restraint system and securing their child to the seat and had found these very helpful. Other people expressed the wish for videos like this for their child seat model. It is therefore recommended that there should be comprehensible and easily accessible instruction videos that explain how to use the child restraint system for all child seat models.

Recommendations to the legislative and executive branches of government

As mentioned above, pictograms on child restraint systems are important sources of information for users. It is up to legislators to make pictograms mandatory on child restraint systems.

The media undoubtedly have an important role to play in providing information to child restraint system users. However, the information provided is often relatively one-sided, because it tends to focus on subjects such as crash tests. Approval tests should address more than just this aspect; further requirements should also be defined, such as: a list of criteria for suitable child restraint systems, a list of key forms of misuse and criteria for the suitability of child restraint systems. In addition, an attempt should be made to break up this one-sided reporting in the media through suitable measures (e.g. regular newsletters to journalists specializing in this area and workshops for them).

Recommendations for research and consumer protection

Specialist shops and advisers play an important role in providing information both in advance of a purchase and when a child seat is purchased. At the same time, the results of this and previous studies indicate that the advice given on child seats is very uneven, and frequently not all the relevant aspects are addressed.

Together with the chambers of industry and commerce, binding standards should be developed for the provision of specialist advice in advance of the purchase of child seats that, in addition to providing general information on securing children in child seats, must also provide information on system-specific peculiarities. Particular importance should be attached, and particular emphasis given, to the problems of misuse. General information is not enough; instead, the specific possibilities of misuse with the child seats a customer is interested in and how to avoid this misuse should be demonstrated. As part of such a procedure, a test fitting would of course be included whenever specialist advice was offered.

Foreign citizens living in Germany were not the focus of this study, but systematic observations in the course of the field research demonstrated that foreign parents (in particular those of south-eastern and southern European origin) must continue to be regarded as a particularly problematic group when it comes to securing children in child seats. This is true not just in terms of misuse but also in terms of non-compliance with the mandatory requirement to secure children under 12 years of age in child seats. Particular aspects have to be taken into account with foreign users: their sociocultural heterogeneity and language barriers, for example. In addition, the recognized authorities in these communities (e.g. cultural centers, religious communities, foreign-language media) must be included in order to legitimize any

campaigns, and at the same time their help must be enlisted to identify suitable people who can help spread the message. It should be noted in this connection that friends and family have an important role to play.

It is essential that information and awareness-raising campaigns provide both general and system-specific information on the correct way to secure children in vehicles. Information on the danger of different forms of misuse and their portrayal in detail should receive the same priority.

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