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A pilot study evaluating the effectiveness of preventing railway suicides by mid-track fencing, which restrict easy access to high-speed train tracks

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ABSTRACT

Background: Suicides in the railway system is a serious health, societal, and transportation concern. Restriction of the access to suicide methods in the form of different physical barriers is a promising approach for suicide prevention. *Method:* Mid-track fencing, which is fencing placed in-between the high-speed and commuter train tracks, was installed at one out of seven stations along a train line outside of Stockholm in the years 2013/2014. The number of suicides at the intervention station was compared to six other stations used as controls, over a total period of 20 years (2002–2021). *Results:* Suicides at high-speed tracks occurring at stations was the major cause of death on the investigated railway line. Prior to the year 2014, the intervention and control stations displayed similar time trends in the number of suicides. After installation of the mid-track fencing in 2014, there was a 62.5% reduction in the rate of suicides occurring at the intervention station. Compared to the six other control stations, the intervention station displayed a significant reduction in the number of suicides during the years 2014–2021 (OR = 0.14, 95%CI 0.013–0.95). Suicides at the railway lines in-between stations were not increased post-intervention. However, nearby control stations showed a 162% increase in suicides after the intervention, suggesting the induction of transfer effects. *Conclusion*: Mid-track fences restricting access to high-speed train tracks may have a large effect on reducing the number of railway suicides at intervention stations, but may also induce an increase in suicides at nearby stations without mid-track fences. *Practical applications:* Partial physical barriers such as mid-track fencing is deemed to be relatively easy and cheap to install (as compared to full barriers; e.g., full height platform screen doors) and should be considered at all stations on railway lines that have high-speed trains passing by.

1. Introduction

Each year there are approximately 1,500 suicide deaths in Sweden (National Centre for Suicide Research and Prevention of Mental ill health (NASP)', 2020). Of these, approximately 130 suicides occur in the transport system overall and ~80 occur in the railway system specifically (Fredin-Knutzén et al., 2020). Aside from the tragic deaths, this phenomena has a negative impact on personnel working at the railway (Giupponi et al., 2019; Tranah & Farmer, 1994) and on passengers witnessing these tragic events. These suicides also affect the efficiency of public and cargo transportation.

In general, there is good evidence for reducing suicides by restrictions of suicide methods (Pirkis et al., 2015) and method substitution rarely counteracts this reduction in full (Zalsman et al., 2016). For this reason, means restriction is an important and recommended strategy for suicide prevention (Mann et al., 2021; Zalsman et al., 2016). In the railway system, means restriction by using full or half height platform doors have been shown to be effective, even though the effect for the latter appears to be smaller (Chung et al., 2016; Law et al., 2009; Ueda et al., 2015; Xing et al., 2019). Some studies also showed an effect regarding trenches located in-between the tracks, or so called "suicide pits" (Barker et al., 2017; Coats & Walter, 1999; O'Donnell & Farmer, 1994). However, there is currently limited evidence concerning other types of prevention measures through means restriction in the railway system (Ryan et al., 2018) and there is a need to

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develop better evidence for suicide prevention strategies and methods (Fredin-Knutzén et al., 2020; Mishara & Bardon, 2016).

In a previous study, Rådbo and Andersson (2012) investigated suicides and other trespass fatalities in the railway system of greater Stockholm and its urban areas. Their main findings showed that most fatalities in Stockholm occurred at station areas and that most victims entered the tracks from platforms. Passing express trains were overrepresented compared to commuter trains. Similarly, a recent Japanese study also found that suicides are more frequent at stations with passing trains (Sueki, 2021). Another study from Stockholm area showed that suicide rates tend to increase near high-speed trains and decrease where fences and noise-barrier walls are installed along tracks (Ceccato & Uittenbogaard, 2016).

Rådbo and Andersson (2012) suggested that preventive measures installed on station areas should be prioritized, at least in the Stockholm region. Indeed, the Swedish Transport Administration (STA) installed fences in 2014 between the tracks used by commuter trains and the tracks used by high-speed trains at one of the stations in northern Stockholm (Fig. 1; refer also to Fig. S1 and S2 in the supplement). This installation, here on referred to as "mid-track fencing," limited easy access to the high-speed trains but not to the lower speed commuter trains. These fences obstruct access to the more lethal high-speed track, even though access to the less lethal commuter tracks remains the same. This type of measure is similar to those mentioned in the Restrail toolbox as "Intermediate fencing between tracks" (Restrail-project, 2015a) or "mid-platform fencing" (Restrail-project, 2015b), thus referring to where the fence is installed. In a questionnaire study (Restrail-project, 2015b), these "mid-platform fences" were rated by traffic safety experts to have a high likelihood of preventing suicide.

However, to the best of our knowledge, mid-track fences have never been evaluated with actual suicides as an outcome. It is reasonable to hypothesize that the mid-track fence installed at one of the stations in Stockholm had a preventive effect. Therefore, the present study investigated the hypothesis that fewer suicides would be observed after installation of mid-track fencing at the intervention station.

2. Data and methods

2.1. Data

Data about suicide and non-suicidal accidents involving persons struck by a train were taken from the register of the STA. This database contains a summary of information regarding suicide and accidents and is based on case reports written by STA-investigators, who carry out extensive investigations for each fatal accident. The case-reports often contain the exact location of the accident, attached photos, tracking of the individuals' movement preceding the accident, and information from the police. The classifications of suicides used since 2015 were also improved, by use of extended psychosocial investigations to resolve more unclear cases (Andersson & Sokolowski, 2021; Fredin-Knutzén et al., 2020).

The data used in this study were extracted from the STA, but were also validated against the information in the case reports for each incident. All events were extracted involving persons that were hit by a train between the years 2002–2021 (n = 65 events in total), from eight consecutive stations at the same line in northern Stockholm area (see also Fig. S1 in the supplement). For example, the data included date of event, station name, location, whether the event was classified as suicide or accident, and outcome of the accident (death, injury, or no injury). We classified events as being at or in the immediate vicinity of the platforms if they occurred up to approximately 25 meters away from the platform area, as this corresponded to the coverage of the mid-track fence at the intervention station.

Fig. 1. Photo of the installed mid-track fence and a high-speed train passing by the intervened station. The lower speed commuter train track which has trains stopping at the station, is to the right of the high-speed train track in the picture. Also refer to the Supplement for a brief discussion about the fence design.

2.1.1. Intervention station

The inclusion criteria was that the station had 1 m high mid-track fences (Fig. 1) partially restricting access to all high speed train tracks at the station and a known date for the installation. The mid-track fences at the included intervention station were installed for both north- and southbound tracks, began to be installed during/at the end of 2013 and was finished at the beginning of 2014 (confirmed by using time-stamped photos). Another station was excluded from the analysis due to uncertainties regarding the installation date of a wider 80 cm high concrete barrier in the mid-track (see Fig. S3 in the supplement). The excluded station had 4 suicides observed during the years 2002–2021, which was relatively less compared to the 10 suicides observed at the included intervention station.

2.1.2. Control stations

The control consisted of six other stations on the same line as the intervention station (see Fig. S1 in the supplement), but having no mid-track-fence or other obstacle separating the commuter train tracks from the high-speed tracks. The inclusion criteria were that they should be as similar as the intervention station as possible. Therefore, all stations had tracks dedicated to the same high-speed trains, the same train frequency, and trains passing at approximately the same speeds. The accessibility to the high-speed tracks at these six stations was the same as for the intervention station prior to 2014, when there were no mid-track fences installed at any of the stations. Suicidal persons were thus able to step out in the same high speed tracks that are passing by the stations, with the same degree of accessibility for all included stations prior to year 2014 (Rådbo & Andersson, 2012).

2.2. Analyses

We hypothesized that the mid-track fence resulted in fewer suicides during the years 2014–2021 at the intervention station, compared to the prior years 2002–2013 and compared to the other six control stations without any mid-track fence (i.e., a one-tailed hypothesis). To assess the relative change in average number of suicides per year between intervention and control stations, a stan-

dard difference-in-differences (DD) regression analysis with the following model and dummy variables [coded 1/0] was used: # suicides = $\beta_0 + \beta_1 * [time_{2014\text{-}2021}] + \beta_2 * [intervention\ station] + \beta_3 * [time_{2014\text{-}2021} \times intervention\ station]$. The DD effect is the interaction-term and regression was conducted by using the *reg* command in Stata v.9.2 (Columbia University Mailman School of Public Health, 2019; StataCorp., 2005). To test the effect with statistical inferences about the count data (number of suicides), we calculated odds ratios and one-tailed Fisher's exact tests for the number of suicides occurring at the intervention station during years 2014–2021 versus 2002–2013, compared to the control stations during the same years, respectively. In addition, we plotted the simple moving averages of the number of suicides per year occurring at the intervention and control stations during 2002–2021 (Fig. 2). Finally, we also conducted a series of secondary analyses to investigate impacts on the results of putative uncertainties.

3. Results

3.1. Majority of rail traffic deaths were suicides at the high-speed train track at stations

There was a total of n = 65 events during the years 2002–2021 at the investigated rail line, wherein both suicides and accidents occurred more frequently at the stations (n = 40 and n = 10; see Table 1), in comparison to the line sections in-between stations (n = 11 and n = 4; data not shown). Furthermore, station suicides occurred mainly on the high-speed tracks rather than on the slower on commuter train tracks (Table 1). For example, among the six control stations there was a total of n = 30 suicides, of which n = 24 (80%) occurred in the high-speed track; this was more than n = 3 fatal high-speed rail accidents observed in total (Table 1). Together, these observations emphasized the importance of preventing station suicides specifically and to consider the high-speed train track in particular.

3.2. Mid-track fencing prevented suicides at the intervention station

In the years prior to the installation of the mid-track fences (2002–2013), the number of suicides occurring at the intervention station and surrounding control stations displayed similar levels (Table 1 and Fig. 2). However, after the installation of mid-track fences in 2014, the levels of suicides displayed a notable difference between the intervention and control stations (Table 1 and Fig. 2). The number of yearly suicides decreased by 62.5% at the intervention station (down from an average of 0.66 to 0.25 suicides/year), while increasing by 162% at the control stations (up from an average of 0.91 to 2.38 suicides/year), which corresponds to a relative reduction at the intervention station of −1.875 suicides/year (Table 1 and Fig. 2). The odds ratio (OR) for the number of suicides occurring at the intervention station during years 2014–2019 versus 2002–2013, compared to the control stations during the same years (2 and 8 *vs* 19 and 11; Table 1), showed a significant reduction in suicides occurring at the intervention station (*OR* = 0.14, 95%CI 0.013–0.95; Fisher's $p = 0.021$). Finally, restricting analysis to the subset of suicides occurring only on the high-speed track at stations (Table 1), also showed a relative reduction of −1.125 suicides/year and a similar OR effect size (*OR* = 0.18, 95%CI 0.003–2.94; Fisher's $p = 0.14$). However, it should also be noted, that half of the suicides on the intervened station occurred in the lower speed commuter train track, which were reduced to a similar extent as the suicides on the high-speed track (Table 1). However, analyzing only suicides at the lower-speed commuter track was not feasible, due to the low counts in the control group (Table 1). Together, results suggested that the mid-track fencing had a suicide preventive effect at the intervened station overall, including an effect on suicides at the high-speed track. However, there was also an increase of suicides at the control stations, which suggest that the mid-track fencing intervention may have induced a transfer of suicides away from the intervention station to the nearby control stations.

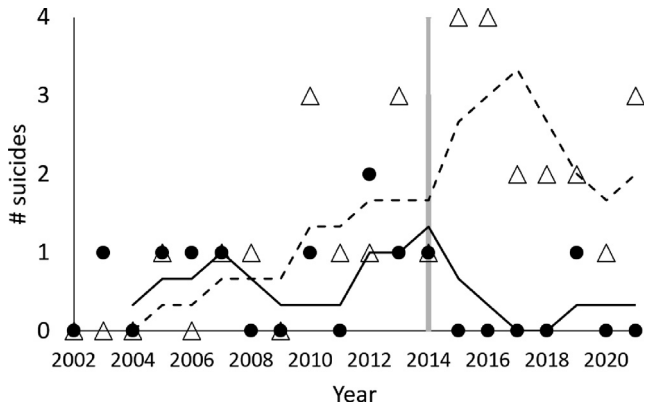

Fig. 2. Suicides at the intervention station (black dots) were apparently reduced after installation of a mid-track fence in year 2014 (vertical grey line), whereas among the six control stations (open triangles) suicides remained high. Solid and dashed lines depict the respective 3-year simple moving averages.

3.3. Secondary analyses supported a suicide preventive effect of the mid-track fencing at the intervention station

First, one of the high-speed track suicides at the intervention station occurred near a wide breach in the mid-track fence (Table 1 and Fig. S4 in the supplement), indicating the absence of a mid-track physical barrier in this case. Repeating OR analysis without this case showed a significant effect also for the high-speed track suicides *per se* (*OR* = 0, 95%CI 0–0.80; Fisher's $p = 0.049$). Thus, we observed a significant effect above despite this flaw in the mid-track fence design. Secondly, during the pandemic years 2020–2021, high-speed trains were periodically cancelled. Nevertheless, repeating analysis without inclusion of these years also showed a relative reduction of −1.92 suicides/year and a maintained OR effect size (*OR* = 0.18, 95%CI 0.002–1.23; Fisher's $p = 0.047$). Thirdly, the installation period of the mid-track fences was ongoing from the last half of 2013 until the first half of 2014. No suicides occurred at the intervention station during this period, but three suicides occurred at the control stations during the autumn of 2013. Nevertheless, repeating analysis without inclusion of this period also showed a relative reduction of −2.13 suicides/year and an improved OR effect size (*OR* = 0.11, 95%CI 0.01–0.73; Fisher's $p = 0.009$). Fourth and finally, there was no increase in the number of suicides occurring along the lines in-between stations in the years 2014–2021 (4 suicides, 0.5 suicides/year), compared to the prior years 2002–2013 (7 suicides, 0.58 suicides/year), suggesting that suicides were not transferred to non-station locations. Together, none of these secondary analyses convincingly negated, but rather supported the observed suicide preventive effect of the mid-track fences at the intervention station.

4. Discussion

The mid-track fences at the intervention station had the effect of reducing suicides, as there was a 62.5% decrease in suicides at the intervention station (from 0.66 to 0.25 suicides/year) which sharply interrupted the slightly increasing pre-2014 trend (Fig. 2). This was not the case for suicides at the control stations

Table 1
Summary of suicides and accidents occurring at the stations.

Year	All suicides		Only suicides in the high-speed tracks		All accidents	
	Intervention station	Control group[a]	Intervention station	Control group[a]	Intervention station	Control group[a]
Before mid-track fencing						
2002	0	0	0	0	1[c]	1[c,d]
2003	1	0	0	0	0	0
2004	0	0	0	0	0	0
2005	1	1	0	1	0	0
2006	1	0	1	0	1	0
2007	1	1	1	1	1[c,d]	2[c,d]
2008	0	1	0	1	0	1[c,d]
2009	0	0	0	0	0	0
2010	1	3	1	2	0	0
2011	0	1	0	1	0	0
2012	2	1	1	1	0	0
2013	1	3	0	3	0	0
Total:	8	11	4	10	3	4
After mid-track fencing						
2014	1	1	0	1	0	0
2015	0	4	0	3	1[c]	0
2016	0	4	0	3	0	0
2017	0	2	0	1	0	1
2018	0	2	0	2	1[c,d]	0
2019	1	2	1[b]	2	0	0
2020	0	1	0	1	0	0
2021	0	3	0	1	0	0
Total:	2	19	1	14	2	1

[a] Sums for the six control stations are displayed.
[b] Occurred near a wide breach in the mid-track fence (Fig. S4 in the supplement).
[c] One (1) fatal accident.
[d] One (1) accident in high-speed tracks.

(Fig. 2) or for accidents at any stations (Table 1). Nevertheless, two suicides still occurred during the post-period (years 2014–2021) at the intervention station. One of these occurred in front of a commuter train as the train started to accelerate from the station, which is an unusual behavior (Ceccato et al., 2021) and did not invoke the mid-track fence acting as a physical barrier. The other suicide occurred at the high-speed train track near a wide breach in the mid-track fence (Fig. S4), which likely prevented the functioning of the mid-track fence as a physical barrier for this case. The overall results of this pilot study suggested that mid-track fencing has a preventive effect on deaths by suicide (which occurred most frequently at the high-speed train track).

The decrease in suicides was not followed by an increase in suicides at the train tracks in-between stations, suggesting that suicides were not simply transferred to those locations. However, there was noteworthy 162% increase in suicides among the control stations between the pre- and post-period years, raising the possibility that some suicides had been transferred to the control stations. Results here suggested that mid-track fencing resulted in 3–4 fewer suicides than expected at the intervention station during 2014–2021, which could have contributed, via a transfer effect, to some of the additional 11–12 suicides occurring at control stations during the same period. This indicates the importance of installing mid-track fencing at all stations along the same commuter rail line, rather than only at one station having the most suicides. Future studies of mid-track fencing at further stations and locations will help to resolve the overall and long-term effect on suicide reduction in the wider railway system.

That mid-track fencing may cause a 62.5% (i.e., 2.7-fold) reduction in suicide occurrence may be regarded as surprising, since access to the commuter trains remains the same and the height of the fence is only one meter (a partial physical barrier). We speculate that the mid-track fence may interfere with the cognitive process during the suicidal act *per se*. Indeed, suicidal subjects have been shown to have a number of different cognitive deficits in, for example, decision making and impulsivity (Deisenhammer et al., 2009; Giner et al., 2016; Gvion et al., 2015; Hadlaczky et al., 2018). The results here are in line with a previous study showing that a minimal structured intervention, which only partly restricts access to the lethal means, had the possibility to prevent suicide (Mohl et al., 2012). The time component is of importance in an acute suicidal crisis, as it has been reported that approximately 50% of suicide attempters make their attempt 10 minutes or less after the first current thought of suicide (Deisenhammer et al., 2009). Furthermore, the fence increases the likelihood of being discovered by other individuals, who may in turn intervene by making contact or calling emergency services. Indeed, precautions against discovery was shown to be a predictor of future suicide risk (Beck & Steer, 1989). These putative psychological effects may be shared with mid-platform barriers, which were ranked as having high likelihood to prevent suicide (Restrail-project, 2015b).

There are several limitations with this study. The most severe limitation is that we only investigated one station and have a small sample of suicides in the study. This exposes our findings to the possibility that the effect was caused by other local changes (e.g., other suicide preventive interventions outside of the railway system). But as far as we know there have not been any such interventions (e.g., changes in access to psychiatric care, or other similar activities in the surroundings of the intervention station). The results should thus be interpreted with caution and future studies involving more stations with mid-track fencing will enable to test if our findings are generalizable and provide better estimates of the effect sizes.

Nevertheless, our study suggests a potential new approach to prevent railway suicides. Mid-track fences are likely to be more technologically simple and cost-effective compared to full physical barriers (e.g., full height platform screen doors), although this was not studied here. It could thus be a suitable alternative for railway

stations having passing high-speed trains, for example, at the main lines near larger cities where there is a mixture of faster and slower train tracks. In the commuter train network of Stockholm, we estimate that it could be a suitable method for ~20 additional stations (~50% of the stations in the network). However, due to the possibility of transfer effects being induced by the intervention, fencing should also be installed at nearby stations as well. If future studies confirm the preliminary results reported here, we believe that mid-track fencing (preferably having no breaches and if possible, having a higher height; e.g., 1.5–2 meters) should be considered when designing railways where high-speed-trains pass by stations at separate tracks, and likely also at stations where the platforms are located on either side of the tracks.

5. Conclusion

Mid-track fencing to restrict easy access to high-speed tracks has not been evaluated previously in the scientific literature using suicide as main outcome. The results of this pilot study suggest that mid-track fencing may have a high effect on the prevention of suicides at stations in the railway-system. Physical barriers such as mid-track fencing appear to be an effective and low-cost approach to preventing suicides at train stations, although findings suggest it may be important to also have them at nearby stations to prevent transfer effects. We believe that further research on more alternative uses of various types of fencing should be highly prioritized within the railway industry.

Conflict of interest

The authors declare no conflict of interest.

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Appendix A. Supplementary material

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