

Change in Suicide Rates in Switzerland Before and After Firearm Restriction Resulting From the 2003 “Army XXI” Reform

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Objective: Firearms are the most common method of suicide among young men in Switzerland. From March 2003 through February 2004, the number of Swiss soldiers was halved as a result of an army reform (Army XXI), leading to a decrease in the availability of guns nationwide. The authors investigated the patterns of the overall suicide rate and the firearm suicide rate before and after the reform.

Method: Using a naturalistic study design, the authors compared suicide rates before (1995–2003) and after the intervention (2004–2008) in the affected population (men ages 18–43) and in two comparison groups (women ages 18–44 and men ages 44–53). Data were received from the Swiss Federal Statistical Office. Interrupted time series analysis was used to control for preexisting temporal trends. Alternative methods (Poisson regression,

autocorrelation analysis, and surrogate data tests) were used to check validity.

Results: The authors found a reduction in both the overall suicide rate and the firearm suicide rate after the Army XXI reform. No significant increases were found for other suicide methods overall. An increase in railway suicides was observed. It was estimated that 22% of the reduction in firearm suicides was substituted by other suicide methods. The attenuation of the suicide rate was not compensated for during the follow-up years. Neither of the comparison groups showed statistically significant changes in firearm suicide rate and overall suicide rate.

Conclusions: The restriction of firearm availability in Switzerland resulting from the Army XXI reform was followed by an enduring decrease in the general suicide rate.

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For historical reasons, Switzerland uses a militia army for its defense. Between training courses, as well as during service on weekends, the militia soldier must store his gun at home, a situation unique in Europe. As a consequence, army-issued guns are available in Swiss homes throughout the year. When soldiers have completed their militia service, they may buy their service weapon for a small fee. Switzerland has a population of 7.5 million inhabitants who own a total of approximately 2 million firearms; thus, approximately every other household owns a gun (1). Most soldiers and veterans have this single military gun and do not possess other firearms. Following the general effect that availability of means predicts the rate of suicide by that means (2, 3), many young men in Switzerland who die by suicide use a gun (4). Between 1995 and 2003, 39% of all suicides among men ages 18–43 in Switzerland were carried out using a gun (data from the Swiss Federal Statistical Office). The military gun thus plays an important role in suicide in Switzerland.

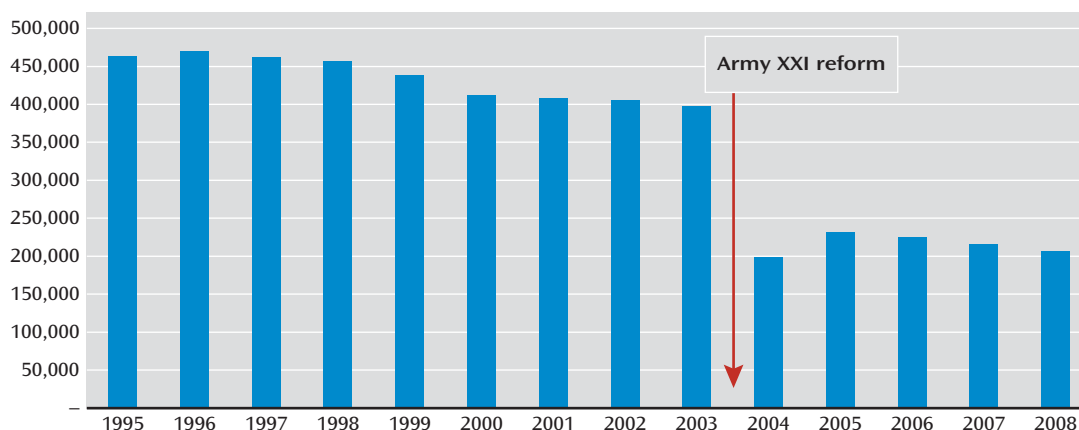
Compared with other European countries, firearm laws in Switzerland are generally less restrictive. All Swiss citizens are allowed to purchase firearms, and a license is required for only a minority of those, but no laws regarding

licenses have been implemented for many years; firearm laws regarding private guns were constant during the period we examined in this study.

In 2003, the Swiss army was restructured by new legislation commonly referred to as “Army XXI.” The reduction of troops from approximately 400,000 to 200,000 (Figure 1), mainly achieved by early discharges, had a significant impact on the availability of military guns. With the Army XXI reform, the discharge age changed from age 43 to age 33. In addition, the percentage of men recruited was lowered. A third aspect of the reform was an increase in the fee soldiers pay to purchase their military gun after service. Moreover, a gun license has been required since then. These factors together may have had a delayed effect on gun availability after a lag of several years.

Given these circumstances, we expected that the Army XXI reform might have had an impact on the numbers of firearm suicides in Switzerland. The reform may be considered a natural experiment that allows the testing of whether restrictions on guns were associated with a decline in the firearm suicide rate. We hypothesized that the reform might also have attenuated the general suicide rate in the affected group (men ages 18–43).

This article is featured in this month's *AJP Audio* and is discussed in an *Editorial* by Drs. Mann and Gibbons (p. 939)

FIGURE 1. Effect of the 2003 Army XXI Legislation on Number of Soldiers in Switzerland^a

^a Data from the Swiss Federal Department of Defense, 2008.

Restriction of means is one of the few evidence-based suicide prevention measures known in public health (5–9). Most studies on restriction have focused on the decrease in the number of firearm suicides (10–15), and only a few have examined the overall suicide rate (16, 17). Other studies have pointed to a method-substitution effect in which other suicide methods substitute for firearm suicide after restriction has been implemented (18–20). It is unknown what proportion of total suicides may be prevented through restriction-of-means interventions. The magnitude of the method-substitution effect will depend on several factors, particularly on the suicide method itself. Suicide by gun has the highest lethality of all suicide methods (21) and is often carried out as an impulsive act. Therefore, we additionally expected that the method-substitution effect would be relatively low for an intervention that reduces firearm suicide compared with other suicide methods.

The availability of guns can be reduced by various interventions (14, 22–25). In general, gun restriction should be most effective when a large number of persons are affected by the intervention. Furthermore, changes can be more precisely detected when an intervention is implemented at a defined point in time and when the restricted suicide method has a high prevalence among all suicide methods in a population. All of the latter circumstances were present in Switzerland in the context of the Army XXI reform: Firearm suicide was the most frequent suicide method in Switzerland; the implementation of the restriction was realized in a short period of time; and the intervention pertained to a large group within a defined population. Therefore, our naturalistic study has considerable statistical power and provides proper conditions to estimate changes in suicide rates after implementation of the reform.

Method

The primary goal of the study was to assess a possible effect of the restriction of firearms that occurred as a result of the Army

XXI reform on both the general suicide rate and method-specific suicide rates in the affected age group, and to compare these rates with rates in other age groups on which the reform would have little or no effect. Additional goals included quantifying the hypothesized preventive effect of the reform as well as the rates of subsequent method substitution.

Data

In Switzerland, suicides are archived by the Federal Statistical Office based on death certificates. We were permitted access to the monthly suicide counts since January 1969. For analysis, we used counts beginning in 1995, when data were registered using ICD-10 codes.

The main analyses focused on the population directly affected by the Army XXI reform. Before 2003, military service started at age 18 and in most cases ended at age 43. Therefore, the Army XXI reform would bear on suicides among men ages 18–43. To adjust for changes in the size of the Swiss population, the primary analyses were conducted using suicide rates (suicides per 100,000 inhabitants per year). The age-specific population statistics from the Federal Statistical Office were used for this purpose. Additional analyses were performed with the numbers of suicides.

The number of army gun holders is not available. However, the number of soldiers is published annually by the Federal Department of Defense, reflecting the count on March 1 of each year. The dramatic reduction in number of soldiers in the army in 2004 can be seen in Figure 1. The Army XXI reform was implemented over the period from March 2003 through February 2004; that 12-month period was therefore excluded from analyses.

Suicide rates may depend on several sociodemographic variables, such as religion, income, unemployment (26), immigration (27), and rates of mental disorders, including substance dependence (28) and use of antidepressants (29). Of these variables, immigration, income, and unemployment rates fluctuated significantly during the study period and may therefore be considered potential confounders. Age-specific unemployment rates were published on a monthly basis by the Swiss State Secretary for Economic Affairs, but no such data were available for the other variables. Hence, unemployment data were analyzed separately to assess confounding effects on monthly suicide rates.

Ethical Considerations

The data we used consisted of completely anonymized archival data from the Federal Statistical Office. In accordance

with Swiss law, such research is not subject to approval by the ethics board of the canton of Bern. The ethics board does not review studies for which approval is not required.

Analyses

Interrupted time series. It is important to detect how closely suicide rates are linked to the intervention studied (30). Interrupted time series analysis allows the investigation of postintervention changes over time (17). The data from the preintervention period can be used to compute a forecast for the postintervention period; in a second step, forecasts can then be compared with observed postintervention data. Interrupted time series analysis, as applied in suicide prevention, reflects two aspects of change following a specific intervention. First, time series can demonstrate whether the intervention was associated with a general decrease in the suicide rate (general effect). Second, time series portray the temporal pattern of an intervention's effect (31), indicating whether it diminished over time, stayed constant, or even increased over time. In this study, interrupted time series were calculated on the basis of the general suicide rate, the rate of firearm suicide, and the rates of suicide by other methods. An intervention effect may be observed in the general or the specific suicide rates, or both.

Regression procedure. We determined which mathematical regression function (linear, quadratic, or cubic) best approximated the time pattern in the preintervention period (March 1995 to February 2003, or 96 months). We then fitted the functions to the data and computed the F values of the respective regression models. On the basis of the best-fitting model, forecasts were calculated for all months of the postintervention period (March 2004 to December 2008, or 58 months) for which the observed monthly rates were available. We compared the forecast values to the observed values by testing the differences (forecast values minus observed values) for all postintervention months against a hypothetical value of zero (constituting the null hypothesis) using one-sample t tests. Thus, positive t values indicate that fewer suicides occurred than was predicted on the basis of preintervention data.

Assessment of validity. We tested the validity of the interrupted time series approach by several alternative statistical approaches. These were performed on the basis of monthly suicide frequencies (not suicide rates as above).

First, we applied Poisson regression because an underlying Poisson distribution (rather than the "normal" Gaussian distribution) may be a more natural assumption in suicide frequencies, especially when they are rare events. The monthly suicide frequencies were used as the dependent variable in a generalized linear model on the basis of a Poisson distribution. Time, cohort size, and intervention (0=preintervention, 1=postintervention) were assessed as predictors in the full model, and log likelihood was computed to evaluate the fit of the model. A chi-square test can then be used to compare the full model with the reduced model—that is, the model without predictors. The contribution of each predictor was evaluated, such that the significance of the intervention predictor would be consistent with a significant role of the Army XXI reform on the suicide numbers.

Second, we computed the autocorrelation function of the frequencies of male firearm suicides and determined the residuals of the time series. The residuals were adjusted for all autocorrelative dependencies so that all temporal dependencies were removed. The residuals of the preintervention months were then directly compared with those of the postintervention months using a t test for independent samples.

Third, we implemented surrogate data analysis on the male firearm suicide frequencies by applying Poisson regression as

above but with a sliding intervention predictor. The factual intervention resulting from the Army XXI reform was implemented from March 2003 through February 2004, so we compared the 96 preintervention months to the 58 postintervention months. In surrogate tests, we dislocated the time period marked by the intervention predictor at steps of initially 3 months, then 6 months, and so on, and repeated Poisson regression analysis for each dislocated "surrogate intervention." Log likelihood was computed to evaluate the fit of each model, and chi-square tests were used to compare the full model with the reduced model (using JMP Pro, version 10; SAS Institute, Cary, N.C.) in each model. Altogether we dislocated the intervention predictor 33 times; that is, the most remote surrogate test assessed a fictional time frame for the intervention as occurring 15 years prior to the factual intervention. Tests thus help detect whether any of the random fluctuations of suicide frequencies in past years were of the same order as the factual shift of suicides at the time of the reform.

Study population (preintervention). Before the intervention, 1,370,208 men (the mean of the preintervention period) 18–43 years of age lived in Switzerland. A total of 1,092 men in that age group died by suicide by firearm during the preintervention period (firearm suicides: 136.5 per year, 9.9 per 100,000 residents per year). The total number of suicides by all methods among men in that age group was 2,822 (352.8 per year, 25.7 per 100,000 residents per year).

The Army XXI reform directly affected only men in the age cohort of 18–43 years. Thus, we hypothesized that no change in suicide rates should be observed in other gender or age groups during the same interval. To analyze whether the effect was indeed isolated as hypothesized, we additionally carried out corresponding analyses with women ages 18–43 and with men ages 44–53. In the preintervention period, the Swiss population consisted of 1,354,800 women ages 18–43 and 504,589 men ages 44–53 (the mean values of the preintervention period). The suicide rate (by all methods) was 7.9 (per 100,000 residents per year) for the female comparison group and 34.8 for the male comparison group. The firearm suicide rate was 0.6 for the female comparison group and 13.0 for the male comparison group. (All data were from the Federal Statistical Office.)

Method substitution. When firearms become unavailable as means of suicide, at-risk individuals may die by suicide by other methods. Four scenarios may be distinguished:

1. No change in the rate of firearm suicide.
2. Complete method substitution (no change in the general suicide rate, but a reduction in the rate of firearm suicide and an increase in the rates of other suicide methods).
3. Partial method substitution (a reduction in the general suicide rate and a reduction in the rate of firearm suicide, but an increase in the rates of other suicide methods).
4. No method substitution (a reduction in the general suicide rate, a reduction in the rate of firearm suicide, and no increase in the rate of other suicide methods).

In the case of partial method substitution, the data will allow us to quantify the magnitudes of the method substitution.

Long-term effects of the intervention. With respect to possible long-term effects of the Army XXI reform, three different scenarios may be observed:

1. Attenuation (a potential positive effect decreases over time)
2. Increase (the effect increases over time)
3. No dynamic effect (no significant attenuation or increase)

To quantify these aspects, we calculated the monthly differences (forecast minus observed values) for the postintervention period, as described above. The resulting time series of difference values (one for each consecutive month) were analyzed using

a linear regression procedure. Such analyses were conducted for general suicide rates, rates of firearm suicide, and rates of suicide by other means among men ages 18–43. We applied Bonferroni corrections to account for multiple testing. All calculations were performed with JMP.

Examination of unemployment and immigration as confounding variables. We tested the influence of unemployment and immigration on suicide rates. The data on unemployment were available only for the 20–45 age group, which meant that a slight difference in the age cohorts was unavoidable. The method of vector autoregression was used (the VARMAX procedure in SAS [SAS Institute, Cary, N.C.]) by which the time-lagged influences between unemployment and suicide rates were estimated. The possible impact of immigration was assessed by tentatively adding the number of male or female immigrants in the Swiss population as a further predictor in the Poisson regression models.

Results

General Prevention Effect and Method Substitution

The overall suicide rate, the rate of suicide by firearm, and the rate of suicide by other methods all decreased throughout the preintervention period (linear regression: $F=8.02$, $df=1$, 95 , $p=0.006$) in the affected age group (men ages 18–43). The regression model showed a superior fit for this linear (negative) trend compared with models that included quadratic or cubic terms. Therefore, the forecasts (expected monthly values) were calculated on the basis of a linear regression. Compared with these forecasts, real observed values were lower for both the overall suicide rate ($t=4.96$, $p<0.001$; mean difference=2.16, $SD=3.32$) and the rate of firearm suicide ($t=11.81$, $p<0.001$; mean difference=2.64, $SD=1.70$). No significant increase was found for suicide by other means after the intervention ($t=-1.27$, n.s.; mean difference=-0.48, $SD=2.85$). On the basis of a composite non-firearm suicide rate, the data did not indicate method substitution. However, when analyzing all suicide methods separately, we found a significant increase in suicide by “jumping in front of a moving object” (usually railway suicides) ($t=-3.43$, $p<0.01$; mean difference=-0.42, $SD=0.93$), yet no signs of substitution in any of the other commonly employed methods (hanging, drug overdose, jumping from a height). All results were Bonferroni-corrected to account for multiple significance testing (Figure 2).

The data indicate that 2.16 fewer suicides per 100,000 inhabitants than expected (95% CI=1.29 to 3.03) occurred in the overall suicide rate of men ages 18–43. Suicides by firearm decreased, against forecasts, by 2.64 per 100,000 (95% CI=2.19 to 3.08), which, on the basis of cohort size, corresponds to 36.7 men in total. There was an increase of 0.48 per 100,000 in suicides using other methods (95% CI=-0.27 to 1.22), or 6.7 men in total. Overall, assuming that the suicide rates of different methods are linked to each other, it can be estimated that 22% of the men in this age cohort who died by suicide substituted a different method for firearms. Hence, a partial method substitution

was supported, which amounts to approximately 30 men in the 18–43 age group in Switzerland each year who did not die by suicide but might have otherwise.

Alternative Methodological Approaches

The Poisson regression approach models the monthly frequencies of suicide events (firearm suicides in men ages 18–43). Suicide frequency was significantly predicted ($\chi^2=143.5$, $df=3$, $p<0.0001$) in the multiple regression model, with intervention ($\chi^2=9.99$, $p=0.002$) and time ($\chi^2=9.41$, $p=0.002$) but not cohort size as significant predictors.

The second approach, based on the autocorrelation function, showed that autocorrelations up to lag 6 (i.e., half a year) were significant. We therefore determined the AR (6) model of the suicide time series and computed the residuals of this model, from which all trends and autocorrelative time dependencies were removed. The regression of intervention and cohort size on these residuals again showed significant prediction by intervention ($t=2.10$, $p=0.037$) but not by cohort size.

In our third approach, comparing all 33 surrogate tests, we found that the factual model yielded the best model as judged by maximum likelihood statistics; the factual model also resulted in the highest chi-square value of the core predictor (intervention) and the highest whole-model chi-square. None of the dislocated surrogate interventions, and hence none of the random fluctuations in the monthly suicide numbers from previous years, resulted in a better model than the actual Army XXI reform intervention (Table 1).

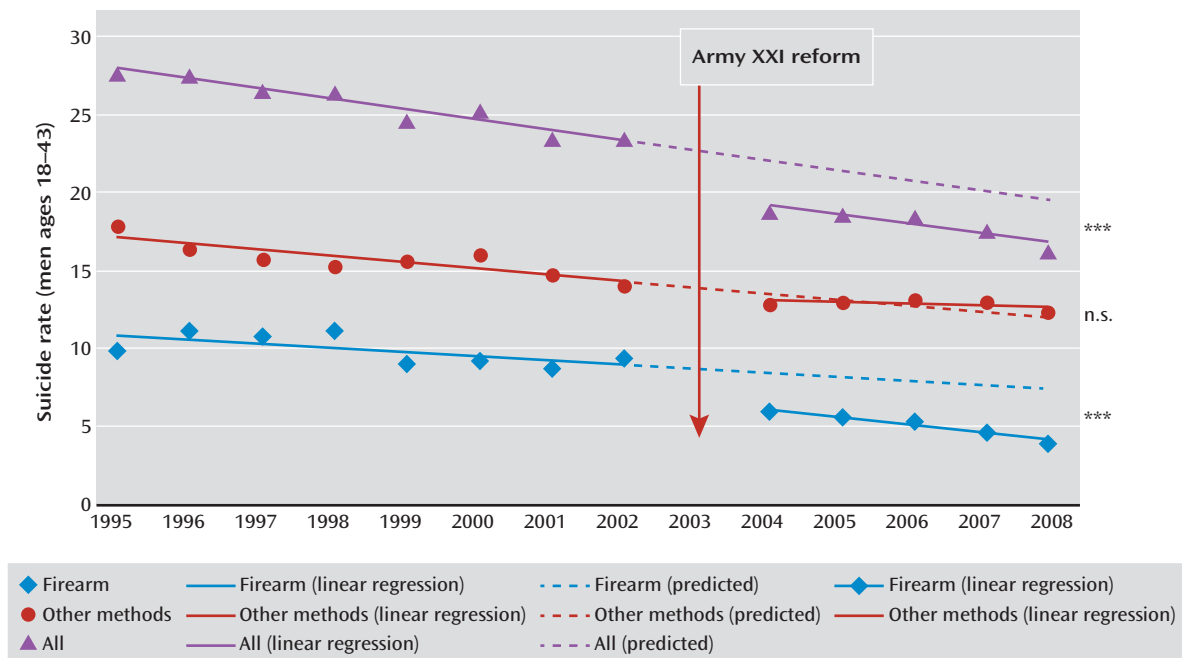
Effect of Unemployment and Immigration

The time series of unemployment as well as that of suicides both decreased in the period 1995–2008. Time series analysis showed that monthly unemployment rates were not significantly associated with suicide. The lag 1, lag 2, and lag 3 impact of unemployment on suicides was nonsignificant. Hence, we found no evidence of a confounding effect of unemployment in men of the relevant age group in the relevant time period.

Addition of the number of male immigrants to Switzerland as a further predictor in the Poisson regression models of suicide frequency in men ages 18–43 again resulted in significant prediction ($\chi^2=135.6$, $df=4$, $p<0.0001$) of the multiple regression model. Intervention was the only significant predictor ($\chi^2=4.79$, $p=0.029$); the predictors immigrant number, time, and cohort size contributed nonsignificantly. Thus, we found no evidence of an explanatory effect of immigration numbers on suicide frequency.

Long-Term Effect of the Intervention

We detected neither attenuation nor an increase of the reduction effect over the years after implementation of the Army XXI reform. The trends in the differences (forecast minus observed data) during the postintervention months were nonsignificant, indicating no time-related changes of the effects associated with the intervention. This was true

FIGURE 2. Suicide Rates in Switzerland Before and After Implementation of the 2003 Army XXI Reform^a

^a The Army XXI reform was implemented during the period from March 1, 2003, to the end of February 2004. Each depicted year reflects the overall suicide rate of a 12-month period starting in March and ending in February of the following year. In 2008, data could be included until December 31, 2008; the suicide rate for 2008 was adjusted accordingly.

*** $p < 0.001$. n.s.=not significant.

for the general suicide rate, the rate of suicide by firearm, and the rate of suicide by other methods. Thus, we found that the observed reduction effect was maintained after the intervention.

Comparison Groups

The female comparison group showed no statistically significant changes in rate of suicide by firearm (mean difference=0.03, SD=0.53), the rate of suicide by other means (mean difference=-0.29, SD=2.22), or the overall suicide rate (mean difference=-0.26, SD=2.35). Observed time series of these variables were therefore not significantly different from forecast values. The comparison group of men ages 44-53 showed a statistically marginal decrease in rate of suicide by firearm (not significant after Bonferroni correction; mean difference=1.43, SD=4.23). We found a significant increase in other methods in this comparison group ($t = -4.85$, $p < 0.001$; mean difference=-4.06, SD=6.38), most prominent in railway suicides ($t = -9.37$, $p < 0.0001$; mean difference=-2.13, SD=1.73). The group's overall suicide rate increased nonsignificantly (not significant after Bonferroni correction; mean difference=-2.63, SD=7.95).

As in the directly affected age group of men, we applied the alternative Poisson regression approach to model the monthly frequencies of firearm suicide events in men ages 44-53 and in women ages 18-43. In the older male group, suicide frequency was significantly predicted ($\chi^2 = 41.2$, $df = 3$, $p < 0.0001$) in the multiple regression model; time was also a predictor but fell short of significance ($\chi^2 = 3.18$,

$p = 0.07$). Intervention and cohort size were nonsignificant predictors. The Poisson regression model for the female group was marginally significant ($\chi^2 = 6.9$, $df = 3$, $p = 0.07$), yet none of the predictors (time, intervention, and cohort size) were significant. Hence, consistent with the interrupted time series approach, both comparison groups showed no significant effect from the Army XXI reform intervention. Addition of immigration numbers to these regression models resulted in analogous findings: none of the predictors, including immigration number, was significant.

Discussion

The Army XXI reform was a legislative intervention introduced in Switzerland in 2003 with the goal of restructuring and resizing the Swiss army. This legislation had, as a side effect, a major impact on the availability of firearms throughout Switzerland, allowing us to estimate the potential effect of a nationwide restriction-of-means intervention on suicide rates. We found a marked reduction in firearm suicide in the directly affected male age group after the intervention. The frequency of firearm suicide in Switzerland had, however, started declining well before the Army XXI reform. These long-standing trends were taken into account by forecasting, and the population of affected men still showed substantial reductions in suicide rates, beyond the forecasts, in the postintervention period. Our analyses therefore support the conclusion that suicide rates have decreased as a consequence of reduced

TABLE 1. Poisson Regression Analysis for the Factual Time of the Intervention and Surrogate Versions of Intervention Timing

Months Intervention Was Shifted Backward	Model Fit: -Log Likelihood ^a	χ^2 for Whole Model	χ^2 for Intervention as Predictor	χ^2 for Time as Predictor	χ^2 for Cohort Size as Predictor
0 (factual)	67.23	134.45	9.99**	9.41**	2.26
3	60.02	120.05	9.45**	7.61**	1.73
6	55.84	111.64	6.87**	7.82**	0.51
9	51.50	103.01	4.13*	9.18**	1.56
12	49.97	99.94	1.20	10.75***	1.05
15	50.05	100.10	0.43	12.25***	2.22
18	47.74	95.48	0.05	13.17***	3.08
24	38.51	77.02	0.51	12.89***	3.56
30	35.51	71.03	1.71	14.82***	4.17*
36	34.24	68.47	0.79	13.59***	3.36
42	28.04	56.08	0.01	11.96**	1.56
48	30.50	61.00	0.05	16.87***	2.56
54	19.62	39.24	1.04	5.21*	0.06
60	16.36	32.72	0.25	4.96*	0.30
66	18.86	37.73	0.01	7.21**	0.09
72	15.20	30.40	0.16	6.29*	0.15
78	13.74	27.49	1.24	7.89**	1.98
84	15.14	30.29	2.78	10.16**	4.47*
90	14.87	29.75	3.36	10.58**	5.46*
96	9.73	19.47	0.61	4.42*	2.87
102	7.55	15.10	0.00	1.91	1.95
108	7.84	15.69	1.13	0.13	0.02
114	5.43	10.87	2.43	0.01	0.09
120	5.11	10.23	2.77	0.01	0.12
126	4.74	9.47	2.71	0.01	0.06
132	4.35	8.69	0.92	0.53	0.57
138	4.18	8.36	0.39	1.54	1.39
144	4.59	9.17	1.16	3.18	0.62
150	6.04	12.08	1.90	3.05	0.39
156	8.00	16.01	4.15*	7.29**	2.72
162	4.14	8.27	2.07	4.97*	2.76
168	2.34	4.69	1.75	2.50	1.43
174	1.75	3.50	0.91	3.35	2.98
180	1.49	2.99	1.08	2.98	2.85

^a Difference: reduced model minus full model.

* $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$.

firearm availability in the wake of a nationwide law. These primary analyses were based on the method of interrupted time series, modeling suicide rates per 100,000 residents per year and assuming normal distribution of suicide rates. We conducted extensive alternative statistical approaches based on the raw data, that is, the suicide counts in the age cohorts of interest. The models of suicide counts assumed Poisson-distributed data. These Poisson regressions yielded results that supported those of the interrupted time series approach throughout: Firearm suicides in men ages 18–43 were statistically linked to the Army XXI reform, whereas those of the comparison groups were not. Surrogate testing additionally suggested that the decrease is not likely an artifact due to random fluctuations of suicide events. The alternative statistical approaches corroborate the validity of the results of the interrupted time series.

The reduction in firearm suicide linked to restricted arms availability is consistent with numerous other studies

investigating this phenomenon (11–15). More importantly, no significant substitution effect was found when all suicide methods except firearms were collapsed, which is in line with several other studies (16, 17). However, when analyzing these methods in detail, the data suggest that some suicides possibly reflect substitution of firearm suicide with jumping in front of a moving object (mainly railway suicides). Thus, interpreting the results cautiously, we found a partial method-substitution effect in which some selective substitution may have occurred. The reduction of suicides was sustained throughout the post-intervention period, with regard to both the overall suicide rate and the firearm suicide rate.

The postulated quantitative reduction of suicides among men ages 18–43 must be considered an important result. Under the assumption that these data are in fact linked, more than three-fourths of the risk group prone to firearm suicide did not switch to another suicide method. Thus,

after the Army XXI reform intervention, approximately 30 fewer young men died by suicide each year in Switzerland.

The female comparison group showed no statistically significant deviations from the predicted values in the general suicide rate, the rate of suicide by firearm, or the rate of suicide by other means. The results for the female comparison group support the adequacy of the chosen statistical method, interrupted time series analysis. The older male comparison group (ages 44–53) also showed no statistically significant effect regarding the firearm suicide rate and the general suicide rate. These findings support the conclusion that the Army XXI reform mainly had a specific effect on the affected age group. However, Bonferroni-corrected results of the male comparison group regarding firearm suicide were close to statistical significance. We therefore cannot exclude the possibility that some effect was also present for the male comparison group. This may be attributed to the fact that military guns stored at home are also accessible to other family members.

The significant increase in other suicide methods in the older male group is more difficult to interpret. It suggests that other factors may have had an impact on the other age cohort, independent of the Army XXI reform. Some suicide methods may have become more prevalent in Switzerland, such as railway suicide and assisted suicide in older age groups. In this light, the increase in railway suicides in the study group may be speculatively linked not exclusively to method substitution but also to other societal factors.

Although our analyses suggest, on the basis of observational data, that the Army XXI reform was associated with a reduction in suicide rates, these post hoc analyses cannot verify a causal relationship between the intervention and the reduction. Investigating prevention with respect to methods other than firearms is desirable but may prove difficult because the necessary circumstances may not present themselves. It is rarely possible to discourage a common suicide method within a whole country, and in a short period of time, as appears to have occurred by the single intervention of the Army XXI reform. In the absence of favorable circumstances, any effects may be shrouded by the natural variance of suicide rates (statistical noise). Yet suicide by gun is often carried out as an impulsive act (32). Assuming that the observed reduction in suicide rates was indeed linked to the Army XXI reform, the results may be best applied to other methods that are also used impulsively, such as jumping from a height or in front of a train (33).

Other limitations should be considered as well. The observed values may be attributed to other factors. The military discharges themselves may have reduced stress in young men. The Army XXI reform reduced the number of militia soldiers, but data on the effective number of guns in households were unavailable. However, very likely the number of soldiers in Switzerland is highly correlated with the number of weapons. One may consider other causes of reducing the prevalence of firearm suicide. Initiatives such as the Alliance Against Depression (34) were staged. Their

influences will be small, however, as the majority of initiatives were launched after 2008, and none had a specific focus on firearm suicide. Moreover, studies have shown that such initiatives often do not reach males (35). In October 2007, the Swiss Federal Council decided to stop the distribution of ammunition to soldiers and started a process to have all previously issued ammunition returned. Our study includes data through the end of 2008, so the effect of restricted ammunition may have exerted some influence on the final months included in our study. Another social development that may have affected suicide rates is immigration (27). Suicide rates may differ between immigrant and native citizens; for example, Turkish immigrants (who are a large immigrant group in Switzerland) have a low suicide rate in Germany (36). Immigrants do not have legal access to army weapons. However, there was no marked change in the trend of immigration to Switzerland, so a linearly increasing confounder due to immigration would have been adjusted by the interrupted time series method. Empirically, we considered immigration numbers as a possible confounding variable in regression models and found no significant predictive value of immigration for suicide numbers in the affected cohort and the comparison cohorts. Hence, the rising number of immigrants cannot account for the decreasing suicide rates. Another limitation of the study is that accidental deaths may have been attributed to suicide. This would be true for both the preintervention and postintervention periods, however. It seems unlikely that such aspects systematically influenced our results. A general limitation of the study is that we did not investigate the influence of the Army XXI reform on homicide rates, as army weapons play a major role in violent deaths in households in Switzerland (37).

The Army XXI reform was not designed or implemented as a suicide prevention effort. Paradoxically, this is a property common to other highly effective interventions in this field, such as the detoxification of household gas in the 1960s (38) and the introduction of catalytic converters in cars (39). The fact that suicide prevention may have occurred as an unintended consequence allows us to exclude the possibility that the reduction in suicide rate was due to causes other than firearms restriction, such as a greater awareness of the suicide problem. This endorses the validity of the results.

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