Effectiveness of a communal, multilevel, interdisciplinary suicide prevention programme

Christine Reif-Leonhard[1]*, Dorothea Lemke[2]*, Franziska Holz[3], Kira F. Ahrens[1], Christoph Fehr[4,5], Markus Steffens[6,7], Michael Grube[8], Christine M. Freitag[9], Sarah C. Kölzer[3], Sabine Schlitt[9], Rebekka Gebhardt[1], Thomas Götz[10], Michael Stäblein[1], Viktoria Dichter[10], Nora Hauschild[10], Inga Beig[10], Louisa Wagner[5], Juliane Müller[1], Ulrich Hegerl[1, 11], Marcel A. Verhoff[3], Juliana J. Petersen[2], Ferdinand M. Gerlach[2], Gil Zalsman[12], Christiane Schlang[1,10#] and Andreas Reif[1,13#]

Affiliations:

[1]Department of Psychiatry, Psychosomatic Medicine and Psychotherapy, University Hospital Frankfurt – Goethe University Frankfurt, Frankfurt am Main, Germany

[2]Institute of General Practice, Goethe University Frankfurt, Frankfurt am Main, Germany

[3]Institute of Legal Medicine, University Hospital Frankfurt – Goethe University Frankfurt, Frankfurt am Main, Germany

[4]Vitos Klinik für Psychiatrie und Psychotherapie Hadamar, Hadamar, Germany

[5]Agaplesion Markus Krankenhaus, Frankfurt am Main, Germany

[6]Klinik Hohe Mark, Frankfurt am Main, Frankfurt am Main, Germany

[7]Catholic University of Applied Sciences Mainz, Germany

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[8]Department of Psychiatry, Klinikum Frankfurt Hoechst, Frankfurt am Main, Germany

[9]Department of Child and Adolescent Psychiatry, Psychosomatic Medicine and Psychotherapy, University Hospital Frankfurt – Goethe University Frankfurt, Frankfurt am Main, Germany

[10]Gesundheitsamt Frankfurt am Main, Frankfurt am Main, Germany

[11]Stiftung Deutsche Depressionshilfe, Frankfurt am Main, Germany

[12]Psychiatry Department, Sackler School of Medicine, Tel Aviv University, Israel

[13]Fraunhofer Institute for Translational Medicine and Pharmacology ITMP, Frankfurt am Main, Germany

* both authors contributed equally to this work.

# both authors contributed equally to this work.

*Corresponding author:

Dr. Christine Reif-Leonhard, Department of Psychiatry, Psychosomatic Medicine and Psychotherapy, Heinrich-Hoffmann-Straße 10, 60528 Frankfurt am Main, Germany; email: Reif-Leonhard@med.uni-frankfurt.de

Abstract

Background: Completed suicide (CS) is among the leading causes for death in the younger age group; overall, around one in hundred people die due to suicide. Suicide attempts (SA) are even more frequent (ten to twenty times) and are a significant contributor to overall morbidity. However, there is only few data on community-based suicide prevention using systemic approaches. To overcome this research gap, we have implemented a communal suicide prevention program in Frankfurt am Main and tested whether it reduced the number of SA and CS, respectively.

Methods: The programme "FraPPE" (Frankfurt project on suicide prevention using evidence-based measures") comprised a bundle of measures that was proposed by previous studies: low-threshold outpatient services, a psychotherapeutic SA postvention program, a hotline targeted at individuals with suicidal intent, qualification of gatekeepers and general practitioners, a campaign to refer SA cases to psychiatric services and anti-stigma campaigns aiming at the general public. Baseline data on CS was obtained from January 2014 to August 2018, and for from of January 2018 to August 2018. The intervention lasted for 25 months.

Results: For CS, on average 7.7 cases per month were recorded during the baseline, comparing to 9 per month cases in the intervention phase. For SA, the numbers were 39.2 and 40.7, respectively. The numbers of CS and SA did not differ significantly between baseline and intervention phases. The most frequent diagnostic group were affective disorders (F3), followed by substance use disorders in both CS and SA. The average age was lower in the SA group as compared to the CS group. More males than females committed suicide ($p<0.001$), whereas the sex ratio was balanced in SA.

Conclusions: The communal suicide prevention measures implemented in FraPPE did not reduce the number of suicides and suicide attempts. This should be interpreted with caution, as already a number of prevention measures were executed in the region, probably underlying a ceiling effect. Also, data were confounded by the Covid-19 pandemic. Finally, our awareness campaign targeted at emergency

personnel might have led to an increased in referrals after SA may also have reduced the dark field regarding the number of SA, leading to increased reporting obscuring a potential decline in the absolute number. We thus propose to enact registries on suicidal behaviors, in order to obtain better data; and furthermore, to develop new preventive measures that more precisely target specific risk groups which might not yet be reached by general measures ("precision prevention").

Keywords: prevention, suicide, suicide attempt, public health, community, trial, time-series

Introduction

Suicide is a relevant global and regional health burden, being a leading cause for mortality especially in the second and third decade of life [1]. Since the 1990s, there has been a significant decline in the number of suicides in most, but not all, developed countries, mainly due to improved depression treatment, de-stigmatisation through awareness campaigns and restrictions of access to suicide means [2]. However, since the last 10 years, the number of suicides has stagnated in most countries of the global North, e.g. at around 10,000 cases per year in Germany [3]. Suicide mortality varies greatly between age and gender groups: the sex ratio is shifted towards males (3:1), and older people in particular belong to the high-risk group—45% of suicide cases were older than 60 years [4]. Older men, accordingly, constitute the group of highest risk; in Germany, the suicide rate for men over 80 years is around six times higher than the average suicide rate [4].

Despite the high societal burden of suicides, suicide prevention is not yet as central to public healthcare as other disease areas. Several individual measures were shown to be effective in preventing suicide, such as restriction to lethal means (in particular, firearms and analgesics), primary care screening and school-based awareness programs [5]. Zalsman and colleagues [5] provided a comprehensive, systematic review on the effectiveness of suicide prevention strategies. A multifaceted approach to suicide prevention, including a combination of education, awareness campaigns, screening, access to mental health services, crisis hotlines, as well as cultural competency, seemed to be most effective in reducing suicide rates. The authors also highlighted the importance of addressing the underlying social, economic, and cultural factors that contribute to suicide risk, such as poverty, discrimination, and social isolation. They also emphasized the need for ongoing research and evaluation of suicide prevention strategies, as well as the need for collaboration between policymakers, healthcare providers, and community organizations to implement effective suicide prevention programs. As the measures found to be effective in this analyses target rather different processes – from awareness to methods restriction – one may assume that a combination of measures (here, called “multi-level intervention”) is more effective than the implementation of just one intervention alone, as also

suggested by the review mentioned above [5]. Synergistic effects, but also different target groups might contribute in this context.

The effectiveness of communal, multi-level, system-based suicide prevention programs, however, has only hardly been tested empirically. This extends to limited knowledge about specific community-based sociodemographic factors correlated to completed suicides (CS) and suicide attempts (SA): while there is extensive data on general risk factors for suicidal behaviors, there is only little data on individually predictive risk within a given city region, hampering targeted prevention. To overcome these research gaps, we have initiated the project "Frankfurt project on suicide prevention using evidence-based measures" (FraPPE) in 2017.

The main objectives of FraPPE were:

1. the reduction of suicide mortality and the reduction of suicide attempts in the city of Frankfurt;
2. study the effects of an interdisciplinary, multi-level, communal suicide prevention program on the prevalence of SA and CS;
3. obtain granular, community-based data on SA and CS.

Primary endpoint of the study was the reduction of CS by 30% between the baseline and the last year of the intervention. Secondary outcome was a reduction in the number of SA between baseline and the last year of the intervention. We here report on the primary and secondary outcome measures. Also, we reflect on the feasibility and acceptance of the suicide prevention project and strive to provide recommendations for further community-based approaches.

Methods

Intervention and study design

The suicide prevention program "FraPPE" builds on the suicide prevention network FRANS—"Frankfurt Network of Suicide Prevention". FRANS was founded in 2014 and is an association of meanwhile more than 75 institutions and organizations having contact to or dealing with suicidal behavior and suicide

prevention. The network has a deliberately interdisciplinary approach, in order to reach as many affected persons as possible. The aims are the development of comprehensive support and coping services, increasing the awareness of the general population and healthcare professionals, the destigmatisation of mental illness, and improvement of data collection, all of which should ultimately lead to the reduction of suicides and suicide attempts.

Between 2014 and 2018 FRANS had four main areas of work: awareness and anti-stigma work (e.g. information stands, readings, website, flyers), training for members of the social professions, collecting suicide figures by evaluating mortuary records and developing concepts for crisis intervention.

FraPPE is a communal multi-center, multi-level intervention study in which, on the one hand, the above mentioned activities of FRANS were continued and expanded (see below). On the other hand, further evidence-based measures were established and evaluated in the city of Frankfurt am Main (inhabitants: ca. 765.000 in 2020). Participating institutions were the University Hospital Frankfurt (Departments of Child and Adolescent as well as Adult Psychiatry, Psychosomatic Medicine and Psychotherapy; Institutes of General Practice and Legal Medicine), and three other psychiatric hospitals providing care in Frankfurt am Main (Agaplesion Markus Krankenhaus, Klinik Hohe Mark, Klinikum Frankfurt Hoechst) as well as the communal health authority (“Gesundheitsamt”) and the Zeitbild Foundation. Interventions were implemented at three different levels (Figure 1): (1) at the individual patient level, (2) for gatekeepers and professionals in the healthcare sector (physicians, emergency services, police, social workers) and (3) at the population level; details are given in the following paragraphs in greater detail:

1) Interventions in the participating psychiatric hospitals

During the intervention phase, low-threshold consultation hours for people in suicidal crises were offered and advertised (as part of FraPPE) in all participating psychiatric hospitals. Outside regular working hours, in case of emergency, patients could contact the psychiatric outpatient departments at any time as part of the routine care, which was highlighted as part of the informational packages of FraPPE. Part of FraPPE was to ensure that staff was trained in guideline-adherent diagnosis and

treatment of mental disorders relevant to suicidal behaviors, and the psychiatric hospitals were responsible for the implementation of guideline-based therapy. As part of FraPPE, a telephone hotline was set up for individuals suffering from acute suicidal ideation (examples of the campaign can be found at www.frappe-frankfurt.de/downloads). The hotline had a local phone number and was serviced by experienced, local psychiatrists 24/7, so that relevant expertise on the assessment of mental disorders, their local treatment pathways as well as suicide prevention was ensured. The hotline and the outpatient services were advertised via a poster campaign, various brochures and leaflets, an information folder for general practitioners (GPs) and a website (www.frappe-frankfurt.de), all being part of the FraPPE multilevel intervention. Details on hotline use (both regarding frequency and content) will be published in a separate paper (in preparation).

As part of FraPPE, all patients after a suicide attempt (SA) seen at one of the hospitals were offered inpatient treatment for diagnostic assessment and initiation of multimodal therapy. The patients received an information brochure on how to deal with suicidal ideation and impulses, as well as an appointment to participate in a psychoeducative group session. When indicated, patients after suicide attempts were offered a specialized psychotherapy program according to the Attempted Suicide Short Intervention Program (ASSIP) [6] which was financed via FraPPE.

ASSIP is a manual-based brief therapy for patients who have recently attempted suicide and has been shown to be efficacious in reducing suicidal behavior [7].It consists of three 60- to 90-minute structured therapy sessions with specific therapeutic interventions including: a narrative interview recorded on video during which patients were encouraged to tell their personal stories about how they reached the point of attempting suicide; video-playback and reconstruction of internal experiences leading to suicidal action; a psychoeducation handout; a case conceptualization collaboratively written from the viewpoint of the patient; and the identification of personal safety strategies, warning signs and long-term goals that were also handed out in form of a credit-card-sized leaflet. As part of the intervention, participants were also sent letters over a period of two years reminding them of the importance of the safety strategies. In accordance with prior research, patients with psychotic

disorders, severe cognitive impairment, habitual self-harm behaviour and insufficient mastery of German or English languages have been deemed ineligible to partake in the therapy.

All patients were provided with guideline-adherent standard-of-care pharmacological, psychological and psychosocial treatments.

2) Qualification of gatekeepers and general practitioners.

A training course for GPs was developed within the FraPPE framework, which was also offered to other healthcare professionals. Furthermore, we developed a so-called "Medical" (see Supplementary Material), including information aimed at doctors, an information leaflet for patients, a flowchart detailing local care pathways in case of acute suicidality, and hotline information, and the PHQ-9 [8] screening self-test, which has been sent to more than 100 GP practices within Frankfurt am Main. In addition, two articles [9,10] on suicide prevention in GP practices were published in specialist journals and an information brochure for GPs and their patients was produced, which was distributed free of charge to selected (usually trained) practices. All materials can be found online at https://frappe-frankfurt.de/downloads.

A poster campaign (see https://frappe-frankfurt.de/ as well) was developed and rolled out as part of FraPPE to raise awareness about suicidal behaviors, especially targeted at emergency rooms, intensive care units and other emergency personnel to increase the rate of referrals to mental health services after SA.

Regarding the non-medical sector, the Frankfurt Network for Suicide Prevention (FRANS) has developed a concept for a training curriculum aimed at employees of the network's member organizations and institutions (e.g. psychosocial contact and counselling centers, self-help associations, teachers and school personnel, municipal offices, police and fire brigade) as well as relevant target groups to be additionally addressed for the respective contents. Workshops dealing with suicidality were then offered in the context of FraPPE. This complements previous FRANS training measures.

A two-part study was conducted to examine the networking structures related to suicide prevention in Frankfurt am Main (manuscript in preparation). This included expert interviews with key actors in community psychiatry, guided by a framework developed after testing and refinement, and data collection from FRANS members via a semi-standardized questionnaire. The interviews were analyzed using Kuckartz's qualitative content analysis, with a category system developed both deductively and inductively. Over two years, networking measures were implemented and evaluated to assess changes in professional collaboration and service utilization. Additionally, an 18-month online survey using LimeSurvey was conducted to capture data on the use of outpatient services by suicidal individuals, focusing on essential information to ensure participation.

3) Population based interventions

In order to raise awareness of the issue and debunk myths about suicidality, various awareness and anti-stigma measures were implemented during the project period, including e.g. activities in the context of the World Suicide Prevention Day (information stands, readings and film screenings) but also postcard and poster campaigns. An awareness movie clip was designed for education, sensitization and destigmatisation, to be used for events but also cinemas or local TV. An overview of the events and materials can be found on the website www.frans-hilft.de. All these activities were delivered via FRANS with the financial and organizational support of FraPPE.

The authors assert that all procedures implemented in this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. As only routine data were collected, no Ethical Approval and Consent was required according to the Medical Association's professional code of conduct.

Evaluation and monitoring of CS and SA

While the intervention study was initially planned as cluster-randomized trial; due to ethical concerns of one of the reviewers of the grant proposal, the study design was changed to a pre-post design

gathering data from a baseline and an intervention phase. The baseline phase (without any interventions implemented beyond what was already done in the context of FRANS) was different for CS and SA, as we could rely on already existing data for CS.

For CS, the baseline phase consisted of a 56 month (January 2014 – August 2018) retrospective observational period using data from the Municipal Health Authority, and for SA, a run-in/baseline period of 5 months (4th of January, 2018 – August 2018) could be implemented.

The intervention was started on the first of September 2018 and lasted for 25 months. Throughout the project period, SA as well as CS were continuously monitored until the 31st of December 2020.

Primary outcome measures: Completed suicides (CS)

For the baseline phase, death certificates from the Communal Health Authority Frankfurt were analyzed. For this purpose, all the death certificates in the time period from 01/01/2014 until 12/31/2020 reporting suicide within the city limits of Frankfurt am Main were included. From 09/01/2018, this data was used for additional data cross-validation.

According to the consensus definition, CS was defined as intentional self-harm with fatal outcome [11]. All CS cases from the Frankfurt metropolitan area were included, which means that all individuals that committed suicide within the city limits were analyzed, irrespective of their place of residence. During the running time of the project, i.e. from 09/01/2018 on, a forensic pathologist was called to the suicide site [12]. CS was then confirmed in collaboration with the criminal investigators; the diagnostic procedure involved interviews with family members, friends, or acquaintances, as well as medical records and suicide notes. This data, together with data obtained at the Institute of Legal Medicine were compared (and if necessary, supplemented) with police investigation results and entered into a case report form (CRF, supplementary material). Whenever possible, the corpse was autopsied at the Institute of Legal Medicine [12]. In all autopsied cases, additional chemical-toxicological examinations were performed to detect medications, alcohol, and drugs in various body fluids and tissue samples;

this data is under analysis and will be reported in a separate paper. Psychiatric diagnoses were, as far as possible, retrospectively reconstructed and coded using the ICD-10 classification. As the overlap between the forensic and the communal data was around 90%, this allowed to obtain the most complete data on CS in Frankfurt/Main up to now. Deaths that could not be clearly attributed to intentional self-harm were excluded.

Secondary outcome measures: Suicide attempts (SA)

According to the international consensus definition, SA was defined as "consciously intended, non-habitual action by which a person wants to bring about his or her death or accepts the possibility of dying" [11] Deliberate self-harm *without* intend to die (non-suicidal self harm, NSSH) was not considered. Whenever a patient was admitted for SA at one of the five hospitals (or it turned out that a SA happened on the same day or one day before admission, or happened during inpatient stay, or a patient after SA was seen within the context of the liaison services), the event was recorded and documented in a 24-item CRF (see Supplementary Material). Thus, all institutions in Frankfurt am Main that provide inpatient mental health care participated in the study. Information of every in- and outpatient presenting after SA was entered into the CRF by the psychiatrist who conducted the admission interview of the patient. The CRF covered data which is routinely collected upon admission: sociodemographic information; SA time, place and method; possible proximal triggers of SA, SA consequences; underlying psychiatric diagnoses; and legal basis for admission. Personnel was trained in completing the CRF in all participating hospitals, and completeness was supported by integrating the assessment in the clinical workflow. Data cross-checks were conducted continuously. Data integrity was also ensured by regularly comparing the CRF with the clinical information system.

Statistical analysis

Number of SA and CS were mainly analyzed using descriptive statistics. In order to adjust for increasing city population over time the suicide risk (or suicide mortality) per 100,000 inhabitants were calculated [13]. Additionally, 95% Poisson confidence intervals were displayed. Primary and secondary outcome analyses consisted of comparison between the baseline and intervention phases. Age, sex, and suicide method stratifications were carried out as subgroup analyses. As a sensitivity analysis, all analyses were carried out excluding suicide victims not having their permanent residence in Frankfurt, as these likely cannot be reached by the implemented measures.

The classification of the suicide methods was based on the ICD codes X60 to X78 [11] and has been grouped into 3 categories: (Fatal) poisoning (X60-X69), including poisoning by various drugs or other substances; strangulation (X70); and (fatal) injuries (X71-X78), which include death by jump, cuts or railway suicides [11].

A logistic regression model for CS and SA was calculated to quantify the influence of age, sex and suicide method on baseline and intervention phases. Overall demographic data for the inhabitants of Frankfurt am Main were obtained from the Office of Statistics of the City of Frankfurt [13].

For data management, statistical analysis, and graphical vizualisation R version 3.6.1 and RStudio version 1.2.5 were used.

Results

Epidemiology of completed suicides and suicide attempts

Descriptive data for all CS and SA are shown in Table 1. Additionally, the numbers of CS and SA cases with a permanent residence in Frankfurt are shown as a subgroup.

For CS, a total of 429 suicides were identified during the baseline phase (on average 7.7 per month), comparing to 222 suicide cases in the intervention phase (i.e., 8.9 per month) (Figure 2). The numbers ranged between 87 and 99 cases per year, and in the subgroup of Frankfurt residents between 69 and

79 cases per year suggesting that a considerable part of suicide victims came from elsewhere. With regard to age and sex distribution, no significant differences were found between the baseline and intervention phases. More males than females committed suicide ($p<0.001$), whereas the sex ratio was balanced in SA (see below). The relative distribution of suicide methods showed a non-significant increase in poisonings (X60-X68) and injuries (X71-X84) in the intervention phase as compared to the baseline, at the expense of strangulations. In 52% of the CS cases (intervention phase), a psychiatric diagnosis could be established retrospectively. The most frequent diagnostic group (according to the ICD main chapters) were affective disorders (F3) at 47%, followed by substance use disorders (F1), schizophrenia disorders (F2) and neurotic disorders (F4). This frequency distribution is similar in the subgroup of cases with permanent residence in Frankfurt. The number of diagnoses per case and stratified by four age groups is shown in Table 2.

A total of 1,213 SA cases were identified during the project period, with 196 cases in the baseline phase and 1,017 cases in the intervention phase. The total number of cases in 2018 [extrapolated] and 2020 (418 vs. 373) shows a similar size, although only 5 months were monitored in 2018 (Figure 2). The average age was lower in the SA group as compared to the CS group ($p = <0.001$), while there was no significant age difference between the baseline and intervention phases. Among the methods of suicidal behavior, poisoning (X60-X68) accounts for the highest proportion in SA. In contrast to the CS group, there was a decrease in injuries (X71-X84) between baseline and intervention phase. The distribution of psychiatric diagnoses shows a similar pattern as in CS: affective disorders (F3) constitute 40% of SA cases, followed by substance abuse (F1), schizophrenia disorders (F2), neurotic disorders (F4), and some personality disorders cases (F6). Many patients suffered from comorbidity, as evident from the number of ICD-10 F diagnoses (Supplementary Table 1).

Interferential analysis of completed suicides (primary outcome)

In order to adjust for the underlying population, age-sex stratified suicide mortality rate (CS) and incidence rate of SA per 100.000 inhabitants were calculated for baseline and intervention phases using 95% Poisson confidence intervals (CI). Additionally, the rates (CS and SA) were calculated for the restricted subgroup of CS and SA with permanent residence in Frankfurt as only those could be reached via the multi-level intervention program. The mean suicide mortality rate (MR) shows no significant difference between the baseline (MR: 12.5, 95% CI: 11.3;13.7) and the intervention phase (MR: 12.4, 95% CI: 10.8-14.1). In Figure 3, the age*sex-stratified mortality rates are displayed. None of the numerical differences were significant. This was also true when only suicide victims with permanent residence in Frankfurt were analyzed (Figure 4): there was no difference in the suicide rate between baseline (MR=9.7, 95% CI: 8.7;10.8) and intervention phase (MR: 9.8, 95% CI:8.3;11.2).

Interferential analysis of suicide attempts (SA—secondary outcome)

The overall incidence rate (IR) of SA per 100 000 inhabitants was 61.8 with Poisson CI of 53.1 and 70.5 in the baseline phase. In the intervention phase, the estimator is reduced to IR: 56.6 95% CI: 53.1; 60.1 which was not significant. The same applies to the subgroup with permanent residence in Frankfurt (IR: 49.1 95% CI: 41.3; 56.8 vs IR: 46.2 95% CI: 40.1; 46.2).

In contrast to the mortality rate, the age-sex stratified IRs of SA (Figure 5) did not increase with age but rather a peak in incidence was observed in the age group of 18 to 29 years in both sexes, which steadily declined thereafter until the age group of 75 years and older. Incidence rates were similar between men and women. No significant difference in incidence rates between baseline and intervention phase were identified. The overall IR was higher in the baseline phase and had wider confidence intervals (IR: 49.1 95% CI: 41.3; 56.8) than in the intervention phase (IR: 43.2 [40.1; 46.2]. Analyzing only cases with a permanent residence in Frankfurt, the same pattern was observed as in the overall sample (Figure 6).

Discussion

Here, we aimed to implement a complex, multilevel, community-based intervention program that considers current evidence-based best practices, to prevent suicidal acts at the communal level in a metropolitan German region, Frankfurt am Main. In order to evaluate the implemented prevention measures regarding their effectiveness, the number of completed suicides (CS) resp. suicide mortality/rate (primary outcome) and the number of suicide attempts (SA) resp. incidence of SA (secondary outcome) were examined. Primary as well as secondary outcomes showed no significant reduction between baseline and intervention phase. Also, the age- and sex-stratified subgroup analyses showed no significant difference between the baseline and intervention phases, arguing that the additional measures which were implemented within FraPPE were not effective in reducing suicidal behavior.

Implemented measures

The interventions that were used in the FraPPE project were derived from previous aggregated evidence [5] and included measures aiming directly at patients, healthcare professionals and gatekeepers, as well as the general public, as detailed in the Methods section. In Frankfurt am Main, a highly active communal suicide prevention network (see https://frans-hilft.de/) has been active since 2014, and a local “Alliance against Depression”, according to the best-practice model and optimizing depression treatment and chain of care [14], was founded in 2015. Thus, numerous community-based interventions were already in place when the FraPPE project started, which is why we decided to implement some additional measures that had not been implemented in Frankfurt, but which were believed to be effective [15]: gatekeeper training, helplines, education of primary care physicians and emergency services. While there was a high demand for training and education courses – including the campaign to refer patients after SA –by emergency services (paramedics, police), the group of GPs was very hard to reach and the participation of GPs in the FRAPPE suicide prevention training accordingly was very low. Quantitative interviews with ten randomly chosen GPs revealed (manuscript in preparation) that they perceive suicide as a relatively minor issue in their practice, with only 0-5 cases

per year. In contrast, they found the "Medical" materials (see Supplementary Material) to be helpful and suggested distributing these via mail or electronically through professional associations. They also recommended offering training through e.g. quality circles, short in-person sessions, or written materials, but showed less interest in webinars or online courses. We suggest that training on mental health and suicide prevention in this professional group has to be implemented in the mandatory training catalogue (in Germany, there is no mandatory training in mental health for GPs). The 24/7 helpline was advertised widely, but it took some time until it was frequently used; however, at present, it receives many supra-regional requests while local effects are limited (manuscript in preparation). Written material such as the information brochure, which has been reprinted several times in the meantime and has been very positively evaluated, was taken up very well. Also, implementation of the ASSIP psychotherapy program was received very positively by patients and therapists alike.

Several highly recommended strategies however could not be used in the present study: restriction to the access to lethal means, which is not possible on the communal level as it involves country-wide legislation (also it must be noted that such restrictions are already quite strict in Germany, especially regarding firearms; this is also evident from analyzing suicide methods, where only few, such as intoxication via over-the-counter medication, could have been prevented by methods restriction); hotspot protection by methods restriction, as this was partially already in place and as up to now, no systematic hotspot analyses were conducted (in fact, these are also part of the present study and will be presented in a separate paper); school-based awareness programs, as our primary target group were adults (please also note the relative small absolute number of suicide cases in children and adolescents [n=9 during the entire period]).

Primary outcome

The primary endpoint of the intervention, a reduction of CS by 30%, was not met. The official suicide statistics for 2021 show a suicide rate of 11.1 suicides per 100,000 inhabitants in Germany [16]. At the federal state level, the rate varies between 7.4 (North Rhine-Westphalia) and 16.1 in Saxony. In

metropolitan areas such as Hamburg or Berlin, the rate is 11.7, and 11.1 respectively. In comparison, the overall suicide rate in Frankfurt am Main during the study period was lower (9.86 per 100,000 inhabitants, based on the analysis of individuals residing in Frankfurt). This might be due to the fact that an already quite effective suicide prevention network was present even before FraPPE started. This might also, at least partially, underly our finding that our intervention package was not effective in reducing CS, as the already high standard of the communal suicide prevention network might have resulted in a ceiling effect, so that the additional measures did not further add to the effectiveness. This might be aggravated by the rather short running time of the project—the intervention phase lasted for only two years—as such complex interventions aiming to change attitudes and behaviors likely will not be effective at such short periods. Further reasons for the disappointing outcome might be the high base rate of individuals committing suicide in states of intoxication and, consequently, increased impulsivity and impaired decision making; population risk groups such as migrants, socioeconomically challenged groups were probably not reached by the measures taken; and finally, therapy-resistant depression and schizophrenia cases constitute a substantial proportion of the affected patient groups. Taken together, such cases generally might underly the stagnation in suicide rates in the last ca. 15 years despite a promising decline after ca. 1980 [17]. To further reduce suicide burden therefore is a huge challenge and requires targeted, precise, and more intensive interventions.

Secondary outcome

Likewise, the secondary outcome was negative in that the number of SA was not significantly reduced. This was not unexpected, as we also conducted an awareness campaign that aimed to increase referral rates from emergency and primary care services after SA into the mental health services. This might well have led to increased awareness and referrals, counteracting an actual decrease in SA number. As only approximately one forth to half of all assumed SA cases (based on the usually given estimate of a 1:10 to 1:20 ratio of CS/SA; [18]) was referred to the tertiary care mental health service (despite the recommendation to do so), the dark field is substantial and confounds any actual effect. There is the

possibility that patients were primarily referred to primary and secondary care services, but given long waiting lists and other hurdles, this likely will not be a large proportion of cases. Having this in mind, it is unclear how to interpret the finding that CS did not statistically change as a consequence of the intervention: did overall numbers decrease, but referral rates increase, or was no change occurring at all? This can only be answered if reporting and documenting all CS cases would be mandatory. This is not yet the case, but utterly needed to obtain meaningful data on CS to govern further interventions and policies. Thus, one important conclusion of our project is to call for obligatory CS reporting in the German healthcare system.

Another intervening factor, for both CS and SA, is the fact that part of the intervention period fell within the time frame of the COVID-19 pandemic. When separately analyzing SA during the pandemic, we could show that these significantly decreased in 2020 as compared to previous years [17,19]. While this might be a consequence of our prevention project, it seems equally likely that effects of the pandemic (perhaps leading to, or in conjunction with changed referral patterns) were underlying this phenomenon; actually, there are indications for the latter explanations as discussed in a previous paper [19]. Also, part of the intervention such as public events, gatekeeper training, anti-stigma campaigns could not or only partially conducted due to the pandemic. Thus, while we consider that our study is clearly negative regarding the primary endpoint, it has to be considered a failed study regarding the secondary outcome for reasons beyond our control (i.e., the pandemic situation). An extension of the study would have been urgently needed, but was not funded by the respective agency. Also, it should be noted that the baseline phase for SA only covered a five-month observation period (due to ethical considerations imposed by the reviewers) and correspondingly, only a few absolute number of SA cases were documented, leading to increased noise.

In contrast to the literature reporting a higher prevalence rate of SA in women compared to men, we found an almost equal rate of SA in men and women. This might be due to specific characteristics of the Frankfurt population, with a comparatively higher number of patients suffering from psychosis

and/or substance use disorder. Since these diseases have a sex bias towards males, there may be a gender shift in suicide attempts. Furthermore, SA in women might have been deemed less serious in females by referring colleagues, leading to reduced referral rates. This should be further investigated, as such behavior would point towards a gender bias in treatment, leading to potentially harmful outcomes.

Comparison to other multilevel suicide prevention programs

Suicide prevention studies that implement complex intervention at the community level are rare with only few exceptions. A well-known example is the OPSI-Europe project [20–22], which aimed to identify and evaluate an evidence-based suicide prevention program which was based on the "Alliance against depression" [14] model and implemented in four European countries. Regarding its main outcome, OSPI-Europe was negative as well; only when Portugal was analyzed separately, a significant reduction in suicidal acts was demonstrated [21]. Considering the positive outcome of the pilot trial in Germany [20], the overall approach of OSPI-Europe may be effective; however, OSPI-Europe mainly comprised measures that were mainly implemented in Frankfurt even before the start of FraPPE via the local "Alliance against Depression" chapter. Other suicide prevention projects that used complex interventions were negative as well: e.g., the cluster randomised controlled community intervention trial MISP-NZ [23] mainly aimed at the training of the primary care sector, and did not yield a significant reduction in suicide rates. In Japan, a complex intervention program aimed at rural regions and showed a reduction suicide rates [23], however, coming from a very high base rate of 71 CS/100.000 inhabitants. When rolled out to densely populated, urban areas, the same program did not significantly reduce CS [24].

Systematic reviews and meta-analyses [5,25–27] that evaluated suicide prevention measures consistently concluded that the most effective means in preventing suicides are training GPs, improving care accessibility, and, most importantly, methods restriction. Given that methods

restriction cannot take place within the framework of a communal prevention project and that care accessibility is already comparably high in metropolitan areas, the most effective measures were already in place in Frankfurt. A cautious interpretation of this study, on the background of existing data, is that measures that were implemented in FraPPE on top of existing programs ("Alliance against depression") are not effective in reducing suicidal acts in metropolitan areas with high standard of care. This however does not deem them useless, as they well might aid in a faster care provision for patients suffering from e.g. depression, thereby reducing disease burden.

Strength & limitations

The study has several strengths and limitations. Among the strengths of this study is that it is a population-based study, in which a comparably large number of CS and SA could be analysed and age- and sex-stratified risk estimates could be calculated. In addition, the involvement of the Institute of Legal Medicine and the Frankfurt Health Department has led to a more reliable estimate of the CS counts. Also, via improved collaboration between the Municipal Authority and the Department of Legal Medicine, the dark field of CS was reduced in that a higher number of cases was detected (around 10%, which has to be considered in the interpretation of the data; manuscript in preparation).

In the case of CS, a long baseline phase (56 months) contrasts with a relatively short intervention phase (25 month). For SA, the opposite is true, which is a clear limitation of the study: a very short three-month baseline phase contrasts with a longer intervention phase (25 month). Therefore, the estimators in the respective shorter phases have a lower precision or a larger range of variation, which leads to a bias in the estimation of the effectiveness of the intervention measures. Also, the nature of the interventions used is such that immediate effects are less likely, but rather a delayed effect seems plausible. As a result, the last year of the intervention is the most important one; however, due to the coincidence with the pandemic, a major confound hampers meaningful analyses. Global meta-analyses [28] as well as own data [29] suggest that rates of CS did not increase in 2020 (or even decreased in

some countries). This is in line with our CS data (which contributed to the above meta-analyses). As already mentioned, a drawback is the pre-post design of the study as opposed to a cluster-randomised trial, so that we cannot rule out secular trends in suicide rates (which, however, were not evident on the national level). Finally, the occurrence of suicidal ideation as such is an important risk factor for SA/CS; reduction of suicidal ideation however would require a different set of interventions as done in the present study and also, measurement of suicidal ideation was beyond the scope of our project. According epidemiological studies should be incorporated in future multi-level intervention programs which also aim at the primary and secondary prevention of mental disorders as such.

Implementing a measure with the goal of reducing suicides with a medium effect size obviously is challenging. As pointed out above, the observation period of three years incl. the baseline is too short to make (statistically) reliable statements about the effectiveness of population-based suicide prevention and postvention interventions. Therefore, an important finding of this study is that population-based monitoring of suicides (e.g., suicide registries) needs to be established to obtain reliable information on risk groups, suicide methods, and spatial distribution of suicide risk and suicide hotspots. Beyond these methodological concerns however, it may be reasoned that such universal or selective prevention measures like we used in the present study are not suitable to reduce suicidal acts below a certain rate, which—in urban settings—seems to be around 10 in 100.000 p.a.. Further optimized mental healthcare provision, increased mandatory training for healthcare professionals, and increased mental health literacy in the general population are, in our opinion, viable measures. Even more important however might be a very target approached aimed at high-risk groups in the sense of precision medicine (or “precision prevention”, in that case). This is a high-hanging fruit, but certainly needed to reduce the high toll imposed on our society by suicidal acts.

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Data availablity.

Raw individual data cannot be provided due to its sensitive nature. Summary statistics can be obtained from the corresponding author.

Conflict of Interest.

AR has received honoraria for lectures and/or advisory boards from Janssen, Boehringer Ingelheim, COMPASS, SAGE/Biogen, LivaNova, Medice, Shire/Takeda, MSD, AbbVie, Novartis, GH Research and cyclerion. Also, he has received research grants from Medice and Janssen and coordinates the German S3 Guideline on Suicidal Behavior, funded by the Joint Federal Committee (G-BA). CRL has received honoraria for lectures and/or advisory boards from Janssen and LivaNova.

Supplementary Material

Supplementary Material: Case report forms (German) for Completed Suicides (CS) and Suicide Attempts (SA). "Medical" educational material for GPs and patients.

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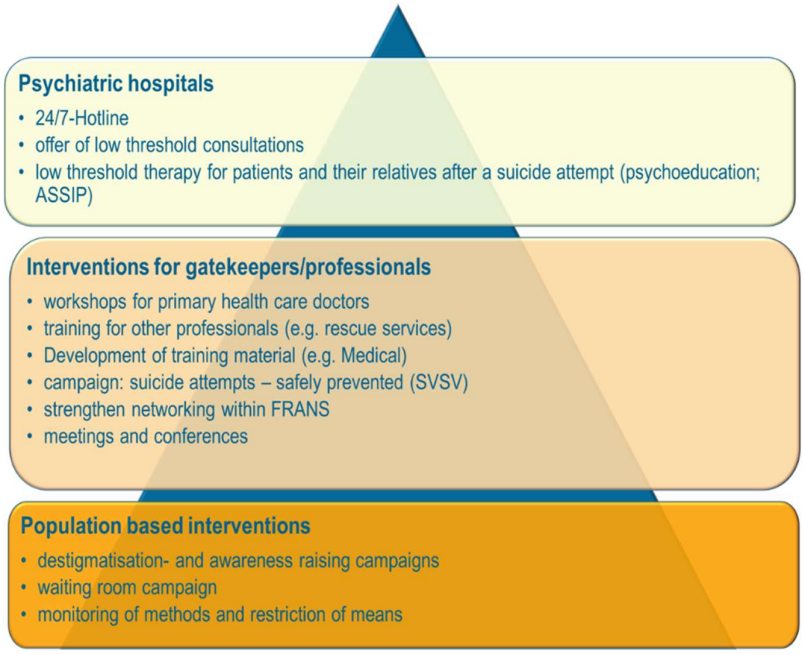

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628 *Figure 1: Overview of the implemented suicide prevention interventions.*

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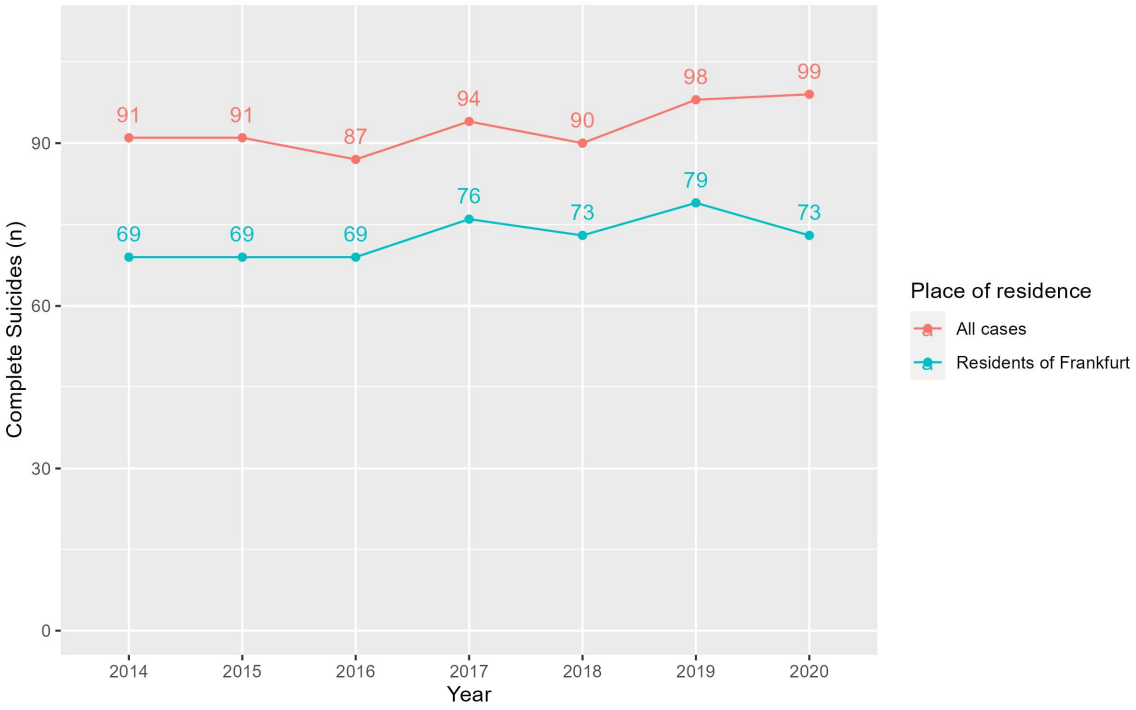

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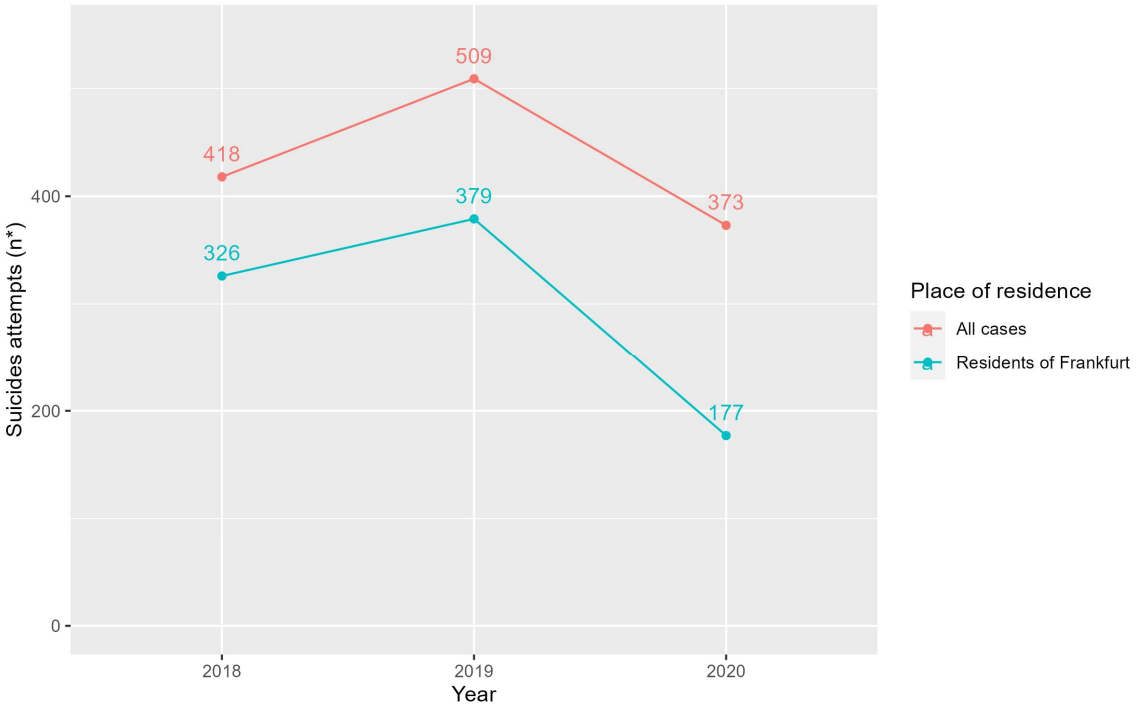

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633 *For presentation purposes, the numbers of suicide attempts in 2018 was extrapolated to the whole
634 year based on the months April to December.

635 *Figure 2: Total count of cases of completed suicides (CS) and suicide attempts (SA) per year.*

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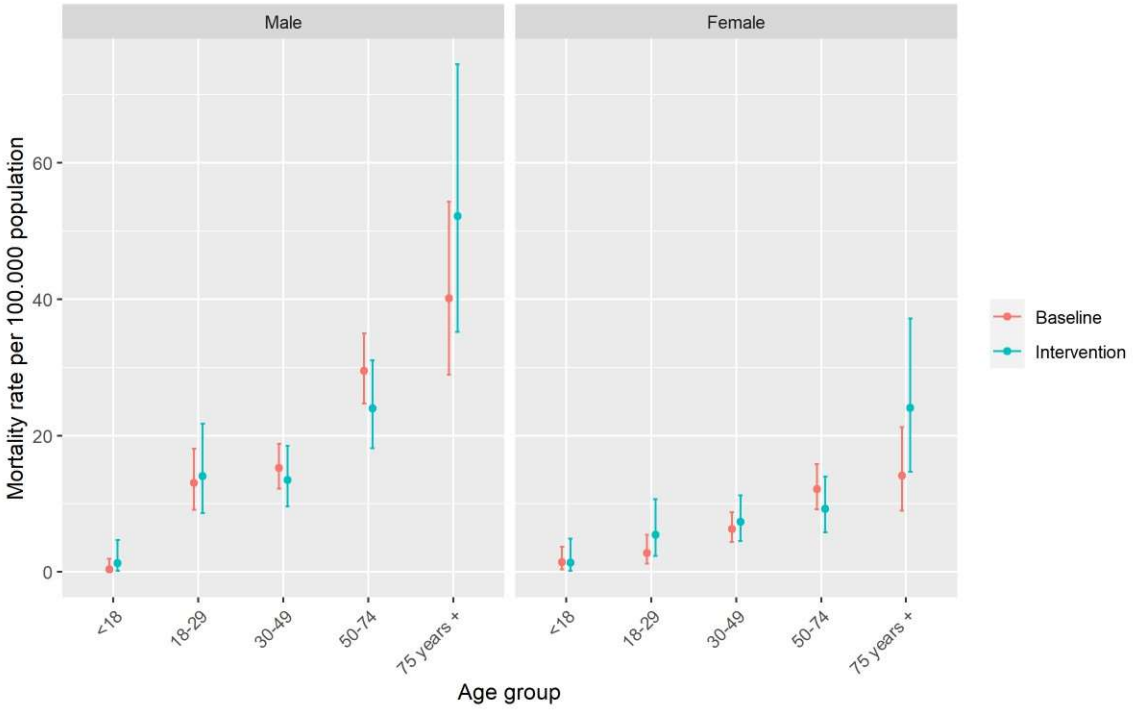

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640 *Figure 3: Suicide mortality rate (MR) per 100 000 inhabitants with Poisson confidence intervals*

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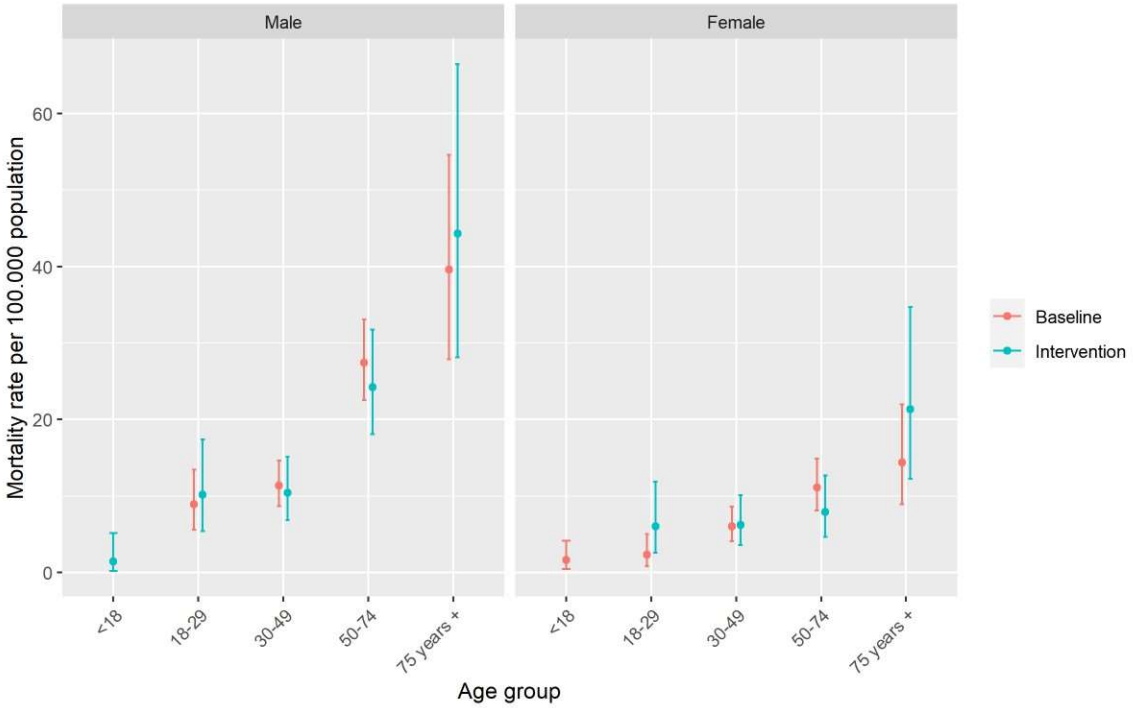

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645 *Figure 4: Suicide mortality rate (MR) per 100 000 inhabitants with Poisson confidence intervals for the subgroup of CS with a*
646 *permanent residence in the city of Frankfurt*

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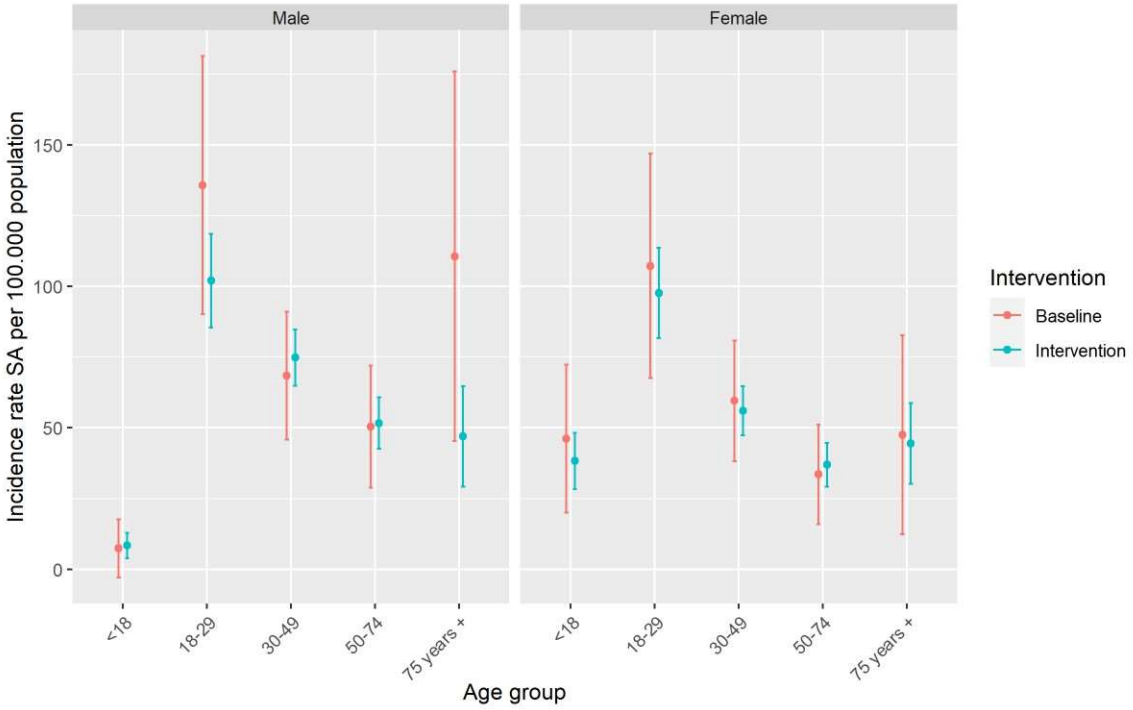

Figure 5: Incidence rate (IR) of suicide attempts per 100 000 inhabitants with Poisson confidence intervals

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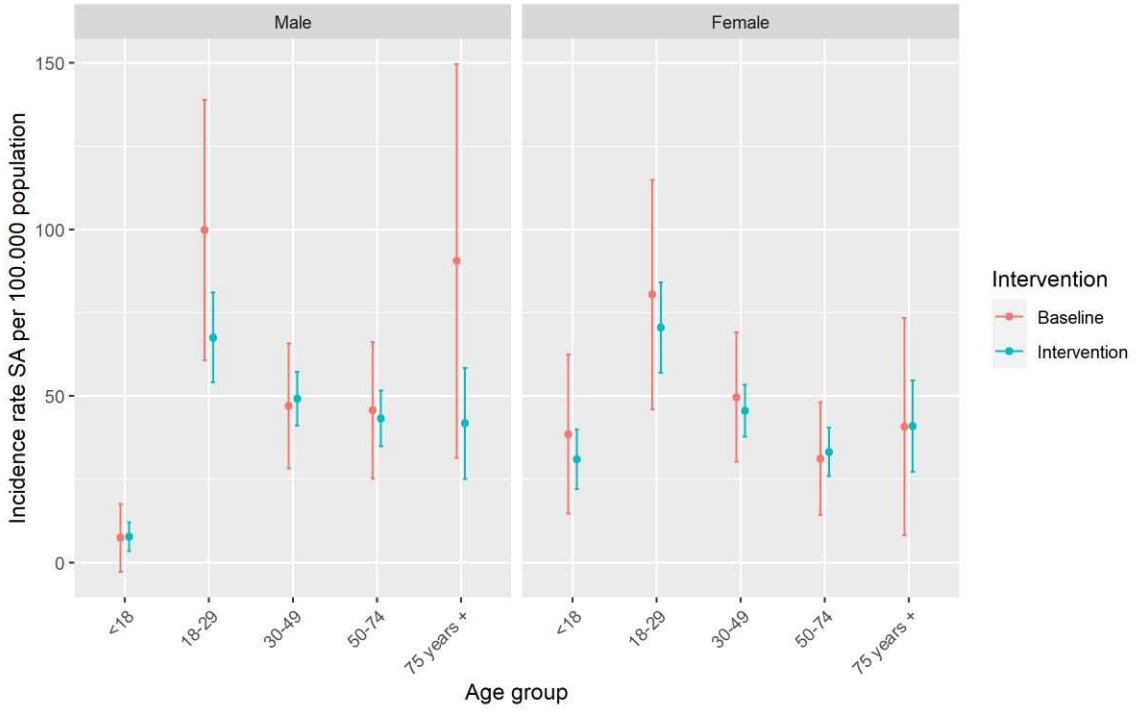

654

655 *Figure 6: Incidence rate (IR) of suicide attempts per 100 000 inhabitants using Poisson confidence intervals for the subgroup*
656 *of SA with a permanent residence in the city of Frankfurt*

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660 **Table 1** gives an overview on CS and SA during the baseline and the intervention phases, including sensitivity analysis (i.e. only CS/SA with place of
661 residence in Frankfurt am Main).

			Completed suicides (CS)						Suicide attempts (SA)					
			All cases (N=649)			Cases with permanent residence in Frankfurt (N=520)			All cases (N=1,213)			Cases with permanent residence in Frankfurt (N=930)		
			Baseline (56 mo) (N=429)	Intervention (25 mo) (N=222)	p-value	Baseline (N=334)	Intervention (N=174)	p-value	Baseline (5 mo) (N=196)	Intervention (25 mo) (N=1017)	p-value	Baseline (N=156)	Intervention (N=774)	p-value
Age					0.625			0.951			0.825			0.684
		Mean (SD)	53.3 (18.5)	54.2 (20.4)		54.9 (18.5)	55.1 (19.7)		39.5 (19.8)	39.8 (18.3)		40.3 (20.6)	40.9 (19.3)	
Sex					0.464			0.893			0.395			0.143
	male	N (%)	300 (69.9)	147 (66.5)		228 (68.3)	117 (67.2)		103 (52.6)	526 (51.7)		79 (50.6)	378 (48.8)	
	female	N (%)	127 (29.6)	74 (33.5)		106 (31.7)	57 (32.8)		91 (46.6)	487 (47.9)		75 (48.1)	394 (50.9)	
	transgender	N (%)	2 (0.5)	-		-			-	3 (0.3)		2 (1.3)	1 (0.1)	
SA/CS method					0.089			0.433			0.075			0.263
	X60-X69	N (%)	80 (18.6)	51 (23.1)		69 (20.7)	46 (24.9)		113 (57.7)	522 (51.3)		88 (56.4)	400 (51.7)	
	X70	N (%)	134 (31.5)	51 (23.1)		110 (32.9)	47 (27.2)		15 (7.7)	57 (5.6)		12 (7.7)	45 (5.8)	
	X71-X84	N (%)	213 (49.7)	119 (53.8)		154 (46.1)	83 (48.0)		68 (34.7)	438 (43.1)		56 (35.9)	329 (42.5)	

Psychiatric diagnoses (ICD10)*					n.a.		n.a.		0.001		0.003
	F0	N (%)	1 (3.2)	1 (2.0)	0	1 (2.1)	8 (4.1)	24 (2.4)	2 (5.0)	4 (1.7)	
	F1	N (%)	3 (9.7)	6 (12.0)	2 (9.1)	5 (10.6)	30 (15.3)	205 (20.2)	6 (15.0)	76 (32.1)	
	F2	N (%)	4 (12.9)	8 (16.0)	3 (13.6)	7 (14.9)	30 (15.3)	145 (14.3)	6 (15.0)	23 (9.7)	
	F3	N (%)	17 (54.8)	23 (46.0)	12 (54.5)	22 (46.8)	60 (30.6)	407 (40.1)	7 (17.5)	67 (28.3)	
	F4	N (%)	3 (9.7)	8 (16.0)	3 (13.6)	8 (17.0)	47 (24.0)	124 (12.2)	15 (37.5)	34 (14.4)	
	F5	N (%)	1 (3.2)	-	-	-	-	5 (0.5)	-	-	
	F6	N (%)	1 (3.2)	2 (4.0)	1 (4.6)	2 (4.3)	20 (10.2)	87 (8.6)	4 (10.0)	24 (10.3)	
	F7	N (%)	-	-	-	-	-	2 (0.2)	-	-	
	F8	N (%)	-	1 (2.0)	-	1 (2.1)	-	1 (0.1)	-	-	
	F9	N (%)	-	1 (2.0)	-	1 (2.1)	-	-	-	-	

*In the CS multiple diagnoses per case are possible and therefore percentage is related to the total number of diagnoses. % numbers relate to the number of cases for which diagnoses were available. No information was available for the CS baseline phase. (F0=organic, mental disorders; F1=mental & behavioural substance abuse disorders; F2=Schizophrenia; F3= affective disorders; F4=neurotic, stress-related & somatoform disorders; F5=behavioural disorders; F7=mental retardation; F8=Disorders of psychological development; F9=Behavioural and emotional disorders with onset usually occurring in childhood and adolescence).