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Efficacy of a digitally supported regional systems intervention for suicide prevention (SUPREMOCOL) in Noord-Brabant, the Netherlands

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ABSTRACT

Objective: We evaluated the effect of a digitally supported systems intervention for suicide prevention (SUPREMOCOL) in Noord-Brabant, the Netherlands.
Method: Non-randomized stepped wedge trial design (SWTD). Stepwise implementation in the five subregions of the systems intervention. Pre-post analysis for the whole province (Exact Rate Ratio Test, Poisson count). SWTD Hazard Ratios of suicides per person-years for subregional analysis of control versus intervention conditions over five times three months. Sensitivity analysis.
Results: Suicide rates dropped 17.8% (p = .013) from 14.4 suicides per 100,000 before the start of implementation of the systems intervention (2017), to 11.9 (2018) and 11.8 (2019) per 100, during implementation; a significant reduction (p = .043) compared to no changes in the rest of the Netherlands. Suicide rates dropped further by 21.5% (p = .002) to 11.3 suicides per 100,000 during sustained implementation in 2021. Sensitivity analysis confirmed the reduction (p = .02). The SWTD analysis over 15 months in 2018–2019 did not show a significant association of this reduction with implementation per subregional level, probably due to insufficient power given the short SWTD timeframe for implementation and low suicide rates per subregion.
Conclusions: During the SUPREMOCOL systems intervention, over four years, there was a sustained and significant reduction of suicides in Noord-Brabant.

1. Introduction

Worldwide, annually more than 800,000 suicides occur [1]. In the Netherlands, suicide rates rose from 8.6 per 100,000 in 2007 to 11.4 per 100,000 in 2016 [2]. Rates in the province of Noord-Brabant were consistently higher than the national average [3]. Noord-Brabant is a province in the south of the Netherlands covering an area of over 4700 km2 with 2.5 million inhabitants. Although Noord-Brabant has five specialized mental healthcare institutions (SMHIs), and 90% of suicides are deemed related to mental disorders [1,4], 60% of those who died by suicide did not receive mental health treatment [5]. However, with good access to treatment, suicide could be preventable [6–8]. For this purpose, a systems intervention for suicide prevention might be a possible solution [9]. A systems intervention aims to create and sustain an environment and conditions supporting a new work method.

To inform the development of a targeted regional suicide prevention systems intervention, we performed a gap analysis by interviewing key stakeholders, such as SMHIs and the chain partners in their catchment area: general practitioners (GPs), nurses, doctors and managers of emergency departments, medical specialists in general hospital outpatient clinics, psychiatrists and nurses in crisis centres and SMHIs, public health and home care professionals, city council members involved in safety and crisis attendance policies, railway officers and train conductors, police, school teachers and University student support services. Stakeholders involved are shown in Fig. 1.

We identified the following challenges. Regarding identification and referral to specialist care of people at risk for suicide, they are in the community, for example, on the street at night, walking along railroad

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tracks, or in schools and universities. Stakeholders in those settings indicated they would have suspicions of suicidal ideation in such persons but lacked the skills to contact them and arrange for appropriate referral to specialist care. Emergency room nurses and physicians confronted with people self-referring because of suicide risk indicated they lacked skills related to suicide risk assessment as well. GPs identified exploring suicidality in the primary care setting, and subsequent referral, as a challenge. Indeed literature shows that 60% of the people who died by suicide had visited their GP in the months preceding their death without their problem being recognized and without referral to a specialty mental health institution (SMHI) for specialist treatment of suicidality [8,10]. So, there is a need to support suicide risk assessment by non-specialized people at the community level, such as railway workers, and non-specialized general health professionals, such as emergency room nurses, with a decision aid.

The stakeholders identified that swift access to specialist care should be provided by prioritizing people with suicide risk, as waiting lists for specialized treatment in SMHIs are long, and suicide risk often is not indicated. Also, the guideline for diagnostic approaches in suicide prevention in the Netherlands lacks instruction about which chain partners should do what in case of suicide risk. So even if patients started treatment in an SMHI for suicidality, they could get lost in transitions between primary care and SMHI departments [11–15], and if someone dropped out of care, nobody would notice. The thinking would be that the other chain partners were in charge. Lack of timely communication between chain partners was deemed essential, given the problems with referrals. Information to chain partners about the need for treatment could be delayed for months or not arrive, making it impossible to act when needed. An active outreaching approach from the SMHI crisis team would be preferable. For that, health professionals should receive information about people at risk in the community as soon as possible. However, there was no regional, fast-working monitoring system for people currently at risk for suicide available for chain partners aiming to prevent suicide.

There is an extensive literature on the difficulties of predicting and categorizing suicide risk. A systematic review found a wide variety of variables and questionnaires being evaluated indicated pooled odds of suicide among high-risk patients compared to lower-risk patients of 4.84 (95% Confidence Interval (CI) 3.79–6.20) when the risk was assessed in psychiatric wards or by mental health personnel in emergency departments [16]. However, our gap analysis showed a need for an algorithm to support non-specialist people in the community or non-mental health nurses in emergency wards to assess risk with a cut-off to safely lead people towards specialist treatment via the monitoring system or to send them back to their GP. Introducing such decision support would improve and standardize the existing triage. Although apps to support suicide prevention have been developed, they focus on the person at risk and a single suicide prevention strategy; no apps providing decision support for gatekeepers in the community or health care professionals were available [17]. The community partners and emergency department healthcare professionals indicated that current practice was that they had to decide which people should be led to specialist mental health care and who could be sent back to their GP, and they felt unsupported in those decisions.

In general, clinical decision aids provide timely information to clinicians, patients and others to inform decisions about health care. Clinical decision support can improve patient outcomes and lead to higher-quality health care [18–20], for example, in the primary care setting regarding treating depressive disorder.

To develop this systems intervention, we were inspired by a regional systems intervention for traffic trauma-related mortality in Orange County, USA. Before implementing that trauma systems intervention, critically injured patients were triaged on the spot and then transported to the closest hospital, but this often did not result in swift, adequate care being provided in the hospital. Hence, they were transported to a specialized trauma centre if that could be done within an hour – the so-called golden hour. Implementing this trauma system significantly decreased preventable deaths [21].

We considered suicide as a preventable death as, in most cases, people who died by suicide did not receive mental health treatment prior to that [6,8]. The gap analysis showed the need for swift access to specialist mental health care, and the assessment needed for that had

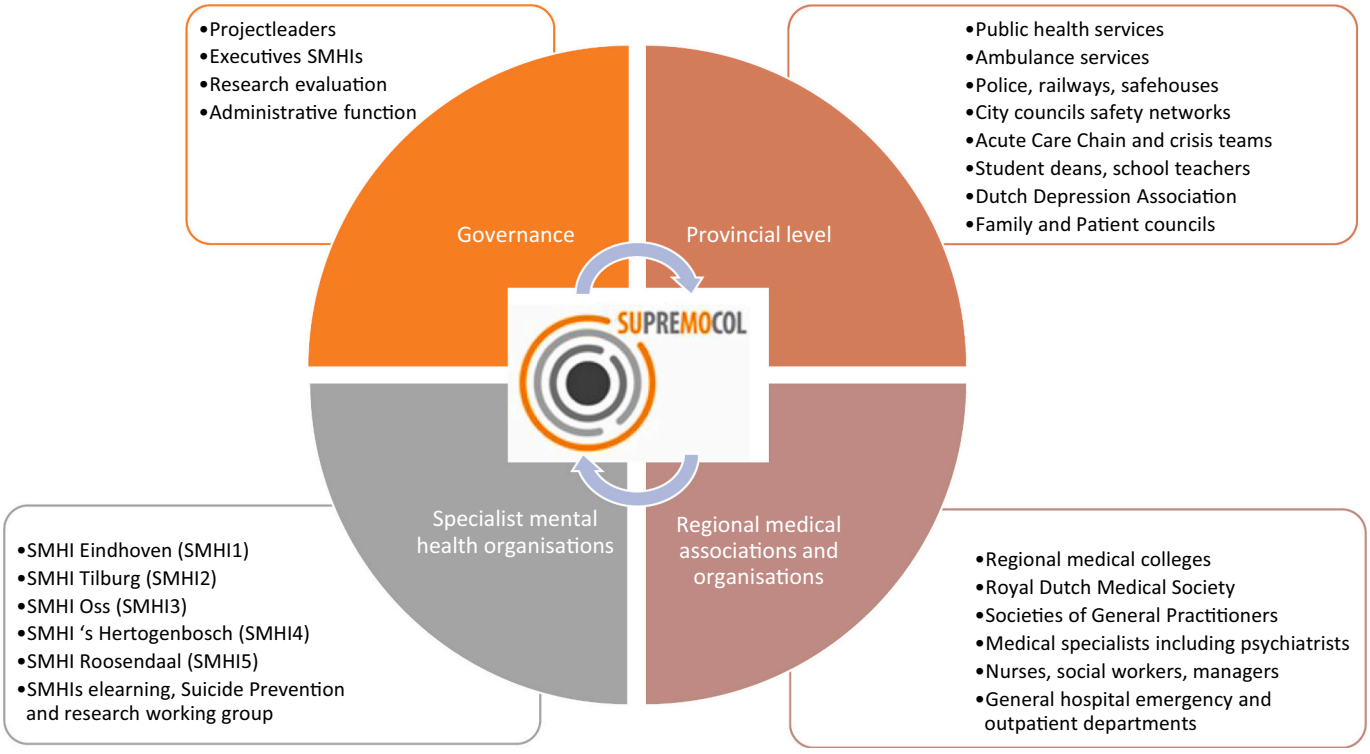

Fig. 1. Stakeholder levels.

similarities with triage on the spot in the trauma systems intervention if supported by a decision aid for the non-specialized healthcare providers and community partners. We, therefore, followed the study example in Orange County by applying their systems intervention model on suicide prevention. The transposition from preventing traffic accident-related trauma death to preventing suicide was discussed and proposed with the chain partners, as illustrated in Fig. 2.

Everybody found at risk, as supported by the decision aid, would follow the step from the emergency department to contact the SMHI crisis team. Further, progression through care would depend on risk ascertainment by the SMHI crisis team supported by the decision aid and potentially involve the indicated steps.

1.1. Objective

We aimed to evaluate whether the systems intervention, compared to the standard care approach, reduced suicides in Noord-Brabant. One objective was to compare suicide rates pre and post-intervention. The second objective was to compare this change to the rest of the Netherlands.

2. Materials and methods

2.1. Intervention

2.1.1. Process of development

A systems intervention aims to create and sustain an environment and conditions that support a new way of work. We adapted this towards a regional suicide prevention intervention involving community and healthcare partners [8] from the subregions during the first year of the study. It was then designed by the research team (CFC and IE), programmed, and tested by healthcare professionals of the crisis teams of several SMHIs who were planning to use the system for feasibility. Their feedback was considered to produce the version used for implementation from year two of the project. The gap analysis identified the following needs in a systems intervention for suicide prevention. Decision support for the triage on the spot to assess suicide risk and decide who would need swift referral to specialist mental health care for suicide risk. This would be provided to community partners in the chain of care such as railway personnel and non-specialized health care professionals. Swift access to specialist mental health care would be provided by prioritizing people known to be at imminent suicide risk. Continuity of care would be provided to people at risk during their transitions to care. Given the difficulties for treatment providers to contact each other directly by phone, this should be supported by a digital decision aid and monitoring system that could be accessed 24/7 by the healthcare chain partners involved [8].

2.1.2. Elements of the intervention

Our systems intervention consisted of four pillars, all supported by the digital decision aid and monitoring system and provided via a desktop computer with a secured login. The data were kept on a secured encrypted server. The number of professionals accessing the system was limited to two per SMHI or other chain partners. They could only see patients in their subregion, not the whole province.

1. People at risk for suicide should be *swiftly identified by triage on the spot* after a non-fatal suicide attempt. This would be done by emergency room nurses, railway personnel, and other community chain partners who had access to the digital decision aid after training. This moment was deemed the "golden hour" equivalent of engaging with the person at risk in the suicide prevention intervention. Based upon earlier research, six questions and an observation incorporated in an algorithm were developed [22–26], as shown in Fig. 3, to identify people at risk for suicide as triage by non-specialized people.

After consent by the person at risk, the patient would be entered into the monitoring system. Within 24 h, a dedicated nurse of the crisis department of the SMHI with access to the digital decision aid would find the new notice and contact the person at risk directly for the next step.

2. *Provision of swift access to specialized mental health care for at-risk people.*

People with moderate or high risk were offered swift access to specialized care as suicide occurs mainly in people not receiving mental health care [10,13] as non-specialized settings are insufficiently equipped to address the suicide risk. This was done by prioritization over other referrals supported by the digital decision aid. People with low risk were advised to make an appointment with their GP.

3. *Accommodating care transitions following a collaborative care approach* [8].

Dedicated SMHI nurses would liaise with treatment providers in primary care and different wards within SMHIs, to ensure continuity of care supported by the monitoring system.

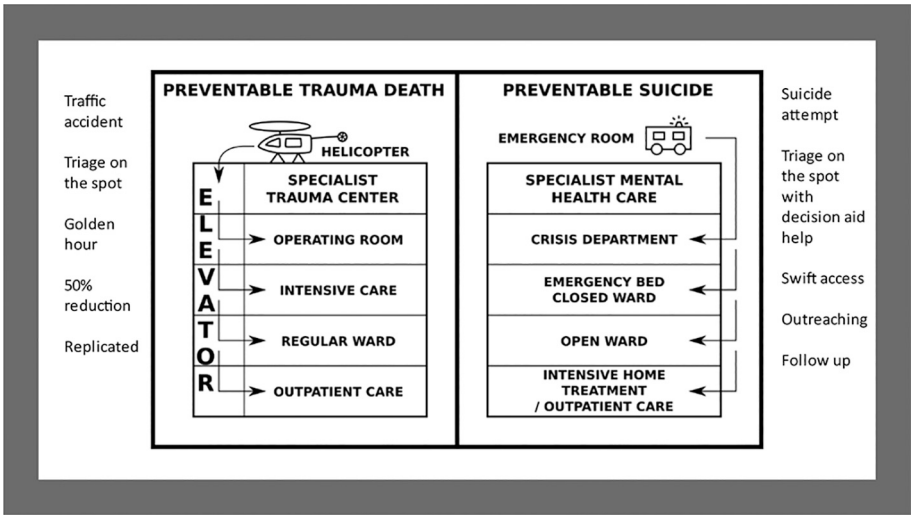

Fig. 2. Systems intervention for Suicide Prevention by Monitoring and Collaborative Care (SUPREMOCOL).

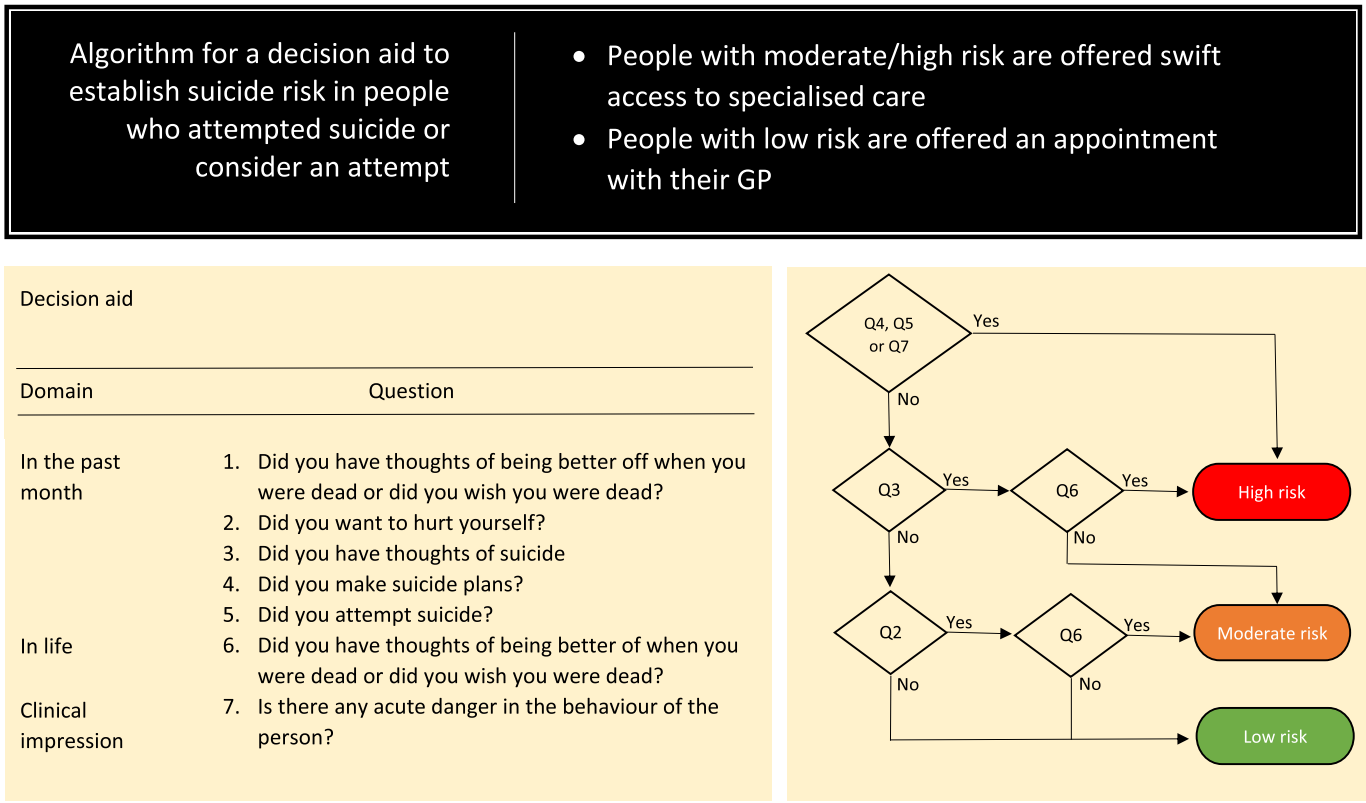

Fig. 3. Assessment algorithm for suicide risk.

4. *Prevention of suicidal attempts after discharge or treatment dropout by 12 months telephone follow-up* [13,14,25,26] by dedicated SMHI nurses.

The digital system would support them, indicating who should be monitored within which timeframe.

This combination of interventions by different providers in multiple domains who communicate utilizing a monitoring system was an essential feature of SUPREMOCOL. It is an example of a multi-level intervention for suicide prevention, having the highest potential for synergistic effect [7].

2.2. Study design and measurement periods

We compared suicides for Noord-Brabant registered by Statistics Netherlands before and after the systems intervention in a pre-post design.

In October 2016, the SUPREMOCOL systems intervention project was launched in Noord Brabant. It started in the first year with the co-design, development and stakeholders testing for bugs in the digital monitoring system and decision aid to identify and monitor people at risk for suicide. From October 2017 until June 2018, this was followed by developing the other three pillars with the chain partners. Then, from June 2018 until September 2019, the systems intervention was implemented stepwise in a stepped wedge trial design (SWTD) in the five subregions (clusters) of specialized mental healthcare institutions (SMHIs) and their chain partners in Noord-Brabant. The evaluation was done in a two-phased follow-up. By September 2020, SMHI3 and SMHI5 stopped collaboration. SMHI1, SMHI2 and SMHI4 and their chain partners continued to follow up with extra funding until September 2021.

For the SWTD analysis, suicides were measured before, during, and after roll-out.

2.3. Stepwise implementation

'Blocks' of subregions were compiled based on the level of implementation and organization of each SMHI and its chain partners. Two blocks were made with two SMHIs; the fifth SMHI stood alone. Per block, preparedness to start with implementation established which SMHI in the block of two would start first with implementation.

2.4. Participants

The target population were people of all ages living in Noord-Brabant. This whole population intervention includes those at risk identified as such and those at risk who were not identified as part of the intervention but who may have been eligible to participate.

2.5. Outcomes

Outcomes were suicides in the province of Noord-Brabant as absolute and relative year records obtained from Statistics Netherlands. This Dutch governmental institution receives all death certificates about injury deaths from coroners [27,28]. For the SWTD, the nominator data consisted of the absolute number of suicides per month and subregion in Noord-Brabant as obtained from Statistics Netherlands Statline. The denominator data were the number of residents in the subregions per month as obtained via Statistics Netherlands [29].

2.6. Statistical methods

To examine changes in suicides before and after the start of the intervention for Noord-Brabant, the relative and absolute numbers of suicides in Noord-Brabant were compared before and after roll-out. The one-year pre-roll-out period (2017) was compared with the one-year roll-out (2018) and the follow-up project duration in 2019, 2020, and 2021 by an Exact Rate Ratio Test, assuming Poisson count. Then those

rates were compared with those in the rest of the Netherlands. As the analysis primarily focusing on one year before implementation versus the entire implementation period might have limited reliability, we conducted a sensitivity analysis comparing the mean suicide rates for three years prior to implementation with the whole implementation period. As such, it allowed us to see the impact of the systems intervention over a more extended period.

The method for the SWTD analysis is described in the supplementary file.

3. Results

3.1. Description of clusters

Block 1 contained two subregions, SMHI1 and SMHI2, with their chain partners. SMHI1 covered a semi-urban area of approximately 796 km2, 15 communities, 555,942 residents, the largest industrial city in Noord-Brabant (229,338 residents), high-tech companies and a technical University. There were one large SMHI, leading the SUPREMOCOL project, and two collaborating general hospitals. SMHI2 was the most densely populated subregion. It covered a semi-urban area of approximately 1035 km2, 20 communities, 882,302 residents, the second and third largest city in Noord-Brabant (215,540 and 183,449 residents), and an industrial region with a University. There were one large SMHI and three general hospitals collaborating in the SUPREMOCOL project.

Block 2 contained SMHI3, which covered the largest rural area of approximately 1645 km2, 18 communities with 568,258 residents, and two smaller cities (90.925 and 90.972 residents, respectively). There were one large SMHI and two general hospitals collaborating in the SUPREMOCOL project. SMH4 covered the smallest area of approximately 220 km2, six communities, 284,949 residents, the fourth largest city in Noord-Brabant (153.436 residents), and the provincial centre. There were one large SMHI and one general hospital collaborating in the SUPREMOCOL project.

The last subregion, SMHI5, covered the second largest, most industrial area of approximately 1093 km2 and six communities with approximately 238,604 residents. There were one large SMHI and one general hospital collaborating in the SUPREMOCOL project. An overview of the subregions is shown in Fig. 4.

3.2. Uptake of the intervention

All SMHIs signed a letter of intent to participate according to the protocol. The intervention uptake increased gradually during the staggered implementation over five subregions. At the end of the trial, all five SMHIs participated with 128 chain partner organizations and a level of implementation based on the four pillars ranging from 88 to 90%. A high level of participation was observed in the railway services, schools, social work, hospitals, and regional organizations of general practices, making successful registrations in the system with a range of accounts for trained, dedicated personnel from 1 to 34 per subregion. The total number of logins per subregion since the start of the implementation in each region until July 2020 ranged from 297 to 1142, and the average number of logins per month ranged from 16 to 50 (28–23 would mean every workday). Swift access was provided in all but one case requiring this during the study.

3.3. Suicide rates in Noord-Brabant compared to the rest of the Netherlands

From 2015, before the start of the intervention, suicide rates went up steadily in the Netherlands as a whole. Noord-Brabant ranked consistently higher than the rest of the Netherlands, ranking second nationally in 2015 and reaching a top rate of 14.4 per 100,000 in 2017. From 2018, the start of the implementation, the rate dropped in Noord-Brabant, stabilized in 2018–2020, and dropped further in 2021. Meanwhile, in the rest of the Netherlands and the Netherlands as a whole, rates remained stable and then went slightly up in 2021, which, combined with the reduction in Noord-Brabant, narrowed the gap between Noord-Brabant and the rest of the Netherlands. The rates in Noord-Brabant, the rest of the Netherlands and the Netherlands as a whole over the years from 2015 to 2021 are shown in Fig. 5.

More detail is provided in Table 1.

Suicides in Noord-Brabant dropped from 14.4 suicides per 100,000

Fig. 4. SubregionsSUPREMOCOL.

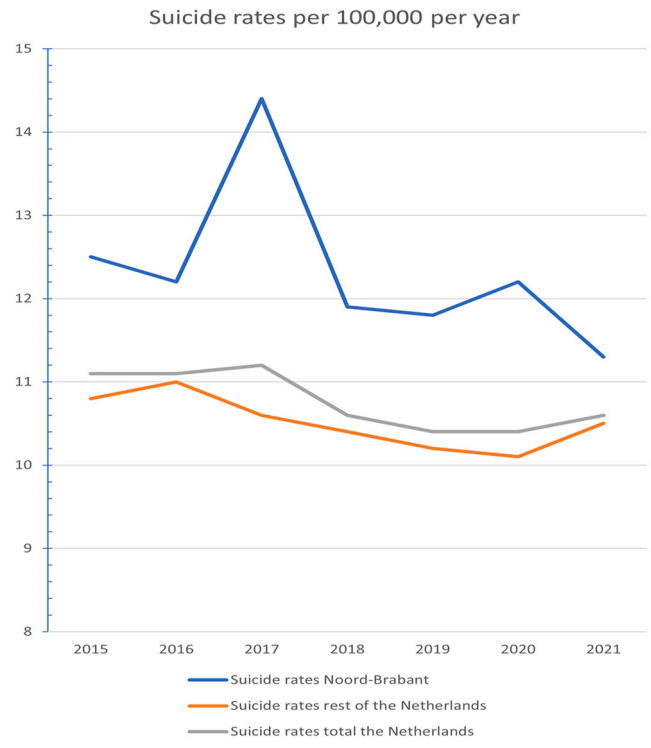

Fig. 5. Suicide rates in Noord-Brabant, the rest of the Netherlands and the Netherlands as a whole over the years from 2015 to 2021 based on Statline data.

(N = 365) in 2017 to 11.9 per 100,000 (N = 302) in 2018, a rate reduction of 17.8% (p = .013). This reduction is significantly lower (p = .043) than in the rest of the Netherlands. The number of suicides remained low during further roll-out (N = 303, rate 11.8 per 100,000 in 2019, and N = 313, rate 12.2 per 100,000 in 2020) and dropped further in 2021 to 294 suicides, with a rate of 11.3 per 100,000; a rate reduction of 21.5% compared to 2017 (p = .002). Changes in the rest of the Netherlands were not significant.

3.4. Suicides during roll-out SWTD analysis

In order to assess if the changes in suicide rates were associated with the implementation at the regional level, an SWTD analysis was performed. The outcomes of this analysis are shown in the supplementary file.

3.5. Sensitivity analysis

The average suicide rate for Noord-Brabant 2015–2017 was 13.1/100,000, and the average for Noord-Brabant 2018–2021 was 11.8/100,000, a significant difference (p = .02). Over the whole period, the rate of suicides per 100,000 residents did not change significantly over time for the Netherlands as a whole and not for the other parts of the Netherlands. The only significant changes, i.e. reductions, are observed in Noord-Brabant when comparing before and after implementing the systems intervention.

4. Discussion

This study describes the results of introducing a regional systems intervention for suicide prevention in Noord-Brabant: SUPREMOCOL. The Stateline year statistics revealed that in 2018, the year in which the roll-out started, for the first time in ten years, the suicide rate in Noord-Brabant showed a significant decline compared to 2017, as much as 17.8%. This decline was significantly larger than the average, non-significant decline in the other provinces. Noord-Brabant dropped in the relative rank of the number of suicides from second place in 2015 to third in 2018. This decline was sustained in 2019, the second year of the systems intervention, and after project extension and prolonged follow-up, suicide rates dropped further over 2021, a total reduction from 2017 of 21.5%. Given that the whole of Noord-Brabant participated in the systems intervention, the finding that suicide rates dropped in Noord-Brabant and remained at that level for the project's duration, and dropped even further during the project extension, might suggest that the SUPREMOCOL systems intervention for suicide prevention is effective.

However, when exploring if there was an association between implementing the systems intervention and suicide rates at the subregional level by the SWTD analysis, no significant relation was found.

Table 1
Suicides and suicide rates per year, for Noord-Brabant, for the rest of the Netherlands, and for the Netherlands as a whole (Statline rates).

	2017	2018	2019	2020	2021
	Suicides	Suicides	Suicides	Suicides	Suicides
	Nr of Residents	Nr of Residents	Nr of Residents	Nr of Residents	Nr of Residents
	Rate per 100,000	Rate per 100,000	Rate per 100,000	Rate per 100,000	Rate per 100,000
		% rate change (p-value)	% rate change (p-value)	% rate change (p-value)	% rate change (p-value)
Noord-Brabant	365	302	303	313	294
	2,528,286	2,544,806	2,562,955	2,573,949	2,592,874
	14.4	11.9	11.8	12.2	11.3
		−17.8% (p = .013)	**−18.1% (p = .011)**	**−15.8% (p = .028)**	**−21.5% (p = .002)**
Rest of the Netherlands	1,552	1,527	1,508	1,510	1,565
	14,652,798	14,737,357	14,844,630	14,901,466	14,997,798
	10.6	10.4	10.2	10.1	10.4
		−2.2% (p = .554)	−4.1% (p = .255)	−4.3% (p = .228)	−1.4% (p = .690)
Total of the Netherlands	1,917	1,829	1,811	1,823	1,859
	17,181,084	17,282,163	17,407,585	17,475,415	17,590,672
	11.2	10.6	10.4	10.4	10.6
		−5.1% (p = .109)	**−6.8% (p = .034)**	**−6.5% (p = .041)**	−5.3% (p = .099)
Phase SWTD	Preparation year	Outroll June 1st 2018–August 30th 2019		End of project Sept 1st 2020	Project continued with extra ZonMw funding by three SMHIs until Sept 1st 2021

Annual resident numbers were reported as per January 1st of the following year. Significant changes compared to 2017 level as established by exact rate ratio test are indicated in bold.

This can be explained in two ways.

Either the significant suicide reduction during the SUPREMOCOL intervention had nothing to do with the SUPREMOCOL intervention. Given that the reduction of 17.8% after one year of implementation and 21.5% after four years of implementation was the first reduction after more than a decade in which Noord-Brabant had higher suicide rates than the other provinces in the Netherlands, factors playing a role in the occurrence of suicides could be expected to even out over the years. An exceptional factor would be required to play a role in such a significant and sustained reduction. Considering this, in the period of this study, there were no separate large regional suicide prevention projects aimed at adults at risk ongoing in the province of Noord-Brabant. No significant social developments, such as changes in employment levels, that might be associated with a drop in suicides at the provincial level occurred [29]. All age and gender groups were included in the analysis, and no significant changes in demographics occurred in Noord-Brabant in that timeframe [30]. Therefore, demographic factors would not seem to have played a role in explaining such a dramatic suicide reduction. Regarding the potential impact of the pandemic on suicide rates, this was monitored in several countries as there were expectations that the number of suicides might rise in 2020 due to the COVID19 pandemic and lockdown [40]. No such rise was found between March 2020 and March 2021 in the Netherlands [31–33]. Internationally, similarly stable or even lower suicide rates in high and middle-income countries in 2020 were reported. [34] Financial support measures and increased social cohesion during the pandemic might have played a role in this. We, therefore, do not consider this a risk factor for suicide rates in Noord-Brabant in 2020 as compared to 2017 or to the rest of the Netherlands.

4.1. Limitations of the study

The other possible explanation could be that a bias or limitation in the SWTD analysis at the subregional level interfered with detecting a relationship between suicide reduction and the systems intervention.

For example, given that suicides are rare events, there may have been enough power to establish a significant decline at the overarching level of the province of Noord-Brabant but not to materialize at a significant level per subregion. Consequently, the SWTD analysis could not detect an association between the reduction in suicides at a provincial level in the pre-post design and the introduction of the systems intervention per subregion.

Methodological shortcomings of the SWTD might have to do with the fact that suicides as outcomes require an analysis by comparing rates, and analytic methods for comparing rates in an SWTD that allow for the exploration of cluster-related factors are limited [35]. This would have been needed as there was a wide variety in suicide numbers per subregion, and we only had five clusters, which precludes exploring predictors at the cluster level. We tried to deal with that by setting up the subregions block-wise, as we could not randomize, allowing for factors like urbanization level, number of residents, and the presence of higher education institutions to be more or less evenly distributed.

Seasonal fluctuations in suicide rates might have interfered with the SWTD design, as some subregions started the intervention when suicide rates were generally low, which is the case in December, and ended when they are generally high, in January and springtime [36]. Although we adjusted for time effects, the possibilities to correct for a seasonal variance were limited given that the analysis concerned the comparison of rates of rare events in a large dataset.

Another potential bias could lie in the extent to which the intervention was implemented, in other words, intervention integrity, that differed between subregions in terms of time preparing to work with the monitoring system, size and organization of the SMHIs in the subregions, availability of linking pins in the organization, attendance of logistical meetings for the chain partners, and engagement with subregional chain partners. SMHIs with more than one crisis department needed more time to set up the new approach than SMHIs with one crisis department. For those, more than three months, as planned for the stepwise SWTD, was needed for full implementation. Hence, during the SWTD, the effects of the intervention were yet to be expressed to the fullest and might have been greater once fully adopted and implemented. This lag period between when the cluster is allocated to start the intervention and full implementation that leads to changes in the outcome target is a well-known problem in SWTDs, as shown in a recent review of 55 studies with implementation problems occurring in 44%, requiring a change of trial duration in 72% of cases [37].

An explanation for the finding that there is a significant decline in suicide rates in the pre-post comparison compared to the SWTD analysis might therefore be that that comparison involves all residents and suicides instead of rates per subregion and covers a longer time span, from 2017 until 2021, compared to the SWTD comparison that spans only 15 months, three months per subregion, in 2018–2019. Hence, the pre-post analysis allows for the organizational changes to have taken place as intended in the SUPREMOCOL intervention and have their sustained effect, which showed in the outcomes of the pre-post analysis.

Another limitation of the study is that initially, it was planned to randomize by compiling ‘blocks’ of subregions based on the level of implementation and organization of each SMHI and its chain partners. However, as the SMHIs were always at a different level of preparedness within each block, block-wise randomization as planned (8) was impossible. Instead, per block, preparedness to start with implementation established which SMHI in the block of two would start first with implementation.

4.2. Strengths of the study

The roll-out of SUPREMOCOL in a province of almost 5000 km2 with over 2.5 million residents, five SMHIs, and their healthcare and community chain partners was a massive effort in itself. Given the context that translating findings from scientific research into practice is a well-known challenge in suicide prevention research [15], it is a strength of the study that we succeeded in doing so, that all SMHIs and chain partners collaborated for the whole duration of the four-year project, and that three SMHIs continued for longer follow up in 2021. The development and roll-out of a systems intervention for suicide prevention in the whole province of Noord-Brabant are, therefore, a novelty and a major strength of this study.

Our study is the first to develop and evaluate a digital decision aid and monitoring system to support community, primary care, and mental health chain partners to find and keep contact with people at suicide risk and to provide them with treatment and support. This innovative intervention is also a strength, as well as the co-design in which the monitoring system was developed. Using national statistics validated suicide rates and rankings for our pre-post analysis is another strength of the study.

The sensitivity analysis showed a consistent finding of elevated suicide rates in Noord-Brabant compared to the rest of the Netherlands over the three years preceding implementing the systems intervention. The sustained drop in suicide rates over the entire duration of its implementation is another strength of the study and suggests that this is a reliable finding.

This systems intervention is an excellent example of how different chain partners can work together towards a goal they deem worthy of their efforts. The co-design with the stakeholders to produce a systems intervention that closely connects to needs and working methods is unique in the Netherlands and worldwide.

4.3. Implications for practice and research

Since the end of funding of the original research project, three of the five SMHIs decided to continue with SUPREMOCOL for another year in 2021. After that, two SMHIs continued and carried the related costs, a major practical implication of the study. The study was mentioned in a

letter from the Ministry of Health to the House of Commons as a positive development [38]. Other regions in the Netherlands joined this effort to explore possibilities for collaboration with the support of the Netherlands Organization for Health Research and Development, which recommended continuing with the implementation [39].

An important facilitator of further implementation is reimbursement by medical insurance companies. During the study, they would not reimburse the monitoring and collaborative care activities of the SMHI nurses, thus forcing the SMHIs to finance this activity themselves. This hampered the implementation of the collaborative care pillar in particular and has influenced some SMHIs to stop collaboration at the end of the project. It makes clear how vital appropriate reimbursement for suicide prevention is. The government labelling suicide prevention as a priority is not a guarantee for this in itself. The national attention, this study's positive findings, and the COVID pandemic's potential impact on mental health and suicidality [40] warrant further efforts and directives to engage medical insurance companies to reimburse SUPREMOCOL-related treatments or activities. Another important stakeholder would be city councils, as they provide services for non-insured and homeless people in municipalities, a group vulnerable to suicide.

Regarding research implications, we need more controlled studies evaluating system interventions for suicide prevention. An SWTD might be less suitable in suicide prevention studies as suicides are rare events and ideally require a Poisson analysis comparing Hazard Ratios. Also, the time lag to implement organizational changes required for setting up a suicide prevention systems intervention may be too long for an SWTD framework in the timeframe of most studies. In terms of design, randomization could still be a study method for SWTDs in case of less complex interventions.

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Institutional Review Board Statement

Trial registration: ICTRP NTR7131 [April 5th 2018] https://trialsearch.who.int/Trial2.aspx?TrialID=NTR7131 The study has been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. The study protocol and amendments have been approved by the Medical Ethics Committee Brabant (#NL6193502817/P1736).

CRediT authorship contribution statement

Christina M. van der Feltz-Cornelis: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Emma Hofstra:** Data curation, Formal analysis, Investigation, Validation, Writing – original draft, Writing – review & editing. **Iman Elfeddali:** Data curation, Investigation, Resources, Supervision, Validation, Writing – review & editing. **Marjan Bakker:** Formal analysis, Methodology, Supervision, Writing – review & editing. **Margot J. Metz:** Investigation, Writing – review & editing. **Jacobus J. de Jong:** Funding acquisition, Investigation, Writing – review & editing. **Chijs van Nieuwenhuizen:** Conceptualization, Funding acquisition, Methodology, Supervision, Writing – review & editing.

Declaration of Competing Interest

The authors declare no conflict of interest.

Data availability

Statline data underpinning the findings are publicly available in Statline. https://www.cbs.nl/nl-nl/maatwerk/2022/32/suicides-noord-brabant-per-subregio-2018-2019 Research data are stored at Tilburg University and comply with the quality infrastructure of Tilburg University. Data is managed and monitored with the required accuracy and organizational and technical measures to protect the processing of data has been taken. The research group will apply the recommended retention period for the data of at least 15 years. After completion of the project, Tilburg University will have governance over the final trial dataset, in compliance with their quality infrastructure.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.genhosppsych.2023.06.010.

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