



Mental health service changes, organisational factors, and patient suicide in England in 1997–2012: a before-and-after study

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Summary

Background Research into which aspects of service provision in mental health are most effective in preventing suicide is sparse. We examined the association between service changes, organisational factors, and suicide rates in a national sample.

Methods We did a before-and-after analysis of service delivery data and an ecological analysis of organisational characteristics, in relation to suicide rates, in providers of mental health care in England. We also investigated whether the effect of service changes varied according to markers of organisational functioning.

Findings Overall, 19 248 individuals who died by suicide within 12 months of contact with mental health services were included (1997–2012). Various service changes related to ward safety, improved community services, staff training, and implementation of policy and guidance were associated with a lower suicide rate after the introduction of these changes (incidence rate ratios ranged from 0·71 to 0·79, $p < 0\cdot0001$). Some wider organisational factors, such as non-medical staff turnover (Spearman's $r = 0\cdot34$, $p = 0\cdot01$) and incident reporting (0·46, 0·0004), were also related to suicide rates but others, such as staff sickness (–0·12, 0·37) and patient satisfaction (–0·06, 0·64), were not. Service changes had more effect in organisations that had low rates of staff turnover but high rates of overall event reporting.

Interpretation Aspects of mental health service provision might have an effect on suicide rates in clinical populations but the wider organisational context in which service changes are made are likely to be important too. System-wide change implemented across the patient care pathway could be a key strategy for improving patient safety in mental health care.

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Introduction

Suicide is a major cause of death worldwide and its prevention is an international priority.^{1–3} Social factors, such as unemployment and wider economic circumstances, are undoubtedly major determinants of suicidal behaviour, and not only at times of recession.^{4–6} However, psychological, biological, and clinical factors are also important.^{7,8} In this context, what role do health services have in suicide prevention?

Adequate access to services and effective management of mental and substance-use disorders have been highlighted by WHO in the global attempt to reduce suicide rates and have been examined in recent studies.^{9,10} Research over many years suggests that most people who die by suicide could be suffering from a psychiatric disorder at the time of death, yet comparatively few are in contact with specialist services.^{11,12} Previous research has identified the characteristics of people who die while under the care of services,¹³ and the elements of mental health service provision that could be associated with reduced rates of suicide, such as ready access to mental health professionals,^{14,15} well developed community services,¹⁶ and

specific policies for substance misuse.¹⁷ Our own previous research found that three service changes in particular (provision of 24 h crisis services, policies for people with drug and alcohol misuse, and a system of reviewing care after suicide deaths) were associated with lower suicide rates in England and Wales after their implementation.¹⁸ Other factors, such as absence of continuity of care and short hospital admission of less than a week, might increase suicide risk.^{19,20}

However, the evidence base is far from consistent—some studies have found no association between service provision and suicide,²¹ whereas others have found that particular service elements, such as levels of compulsory detention, were associated with higher suicide rates.²² Many studies have been purely ecological and have focused on service provision across large areas (eg, country or region) rather than at the level of the individual service provider.¹⁷ Few studies have examined the impact of service changes over time.

Generally, studies have considered few aspects of mental health service provision and have restricted themselves to delivery of care variables rather than

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Research in context

Evidence before this study

We searched MEDLINE and PsycINFO databases from inception to Nov 9, 2015, with a combination of keywords and subject headings (with the terms “suicide”, “suicide, attempted”, and “suicidal”, combined with “policy making”, “reduction”, “organisational policy”, “public policy”, and “health policy” and “mental health services”) to identify published studies in English and systematic reviews on suicide prevention. Studies reported that a number of factors (such as implementation of 24 h crisis services, the presence of community teams, policies for multidisciplinary review after suicide, and follow-up within 7 days of inpatient discharge) were associated with lower suicide rates. Mixed associations were found between suicide and implementation of national substance misuse policies, use and size of inpatient services, and staffing levels. Some aspects of service reorganisation (such as transfer of services or merging specialist teams, or inpatient admissions of less than 7 days) might have been associated with increased suicide risk.

No studies examined the effect of service change in different organisational contexts.

Added value of this study

A number of service changes related to ward safety, community services, training on management of suicide risk, and the implementation of key policies and National Institute for Health and Care Excellence guidance were associated with a lower suicide rate after these policies had been introduced by mental health services. Implementation had a bigger impact in mental health services that had low rates of staff turnover but high rates of overall event reporting.

Implications of all the available evidence

Social, psychological, biological, and clinical factors are crucial determinants of suicide but system-wide change implemented across the patient care pathway could be a key strategy for improving patient safety. Just as important as the changes themselves, might be the organisational context in which these changes are introduced.

considering the way services are organised.²³ Internationally, safety has been highlighted as the first responsibility of health care.^{24–27} Specific recommendations include staff being able to readily raise concerns about the quality of care, an emphasis on learning, and the importance of the strength of the organisation itself (as shown by factors such as staff turnover and patient complaints). Studies in general medical and residential care settings have suggested that poor staff satisfaction and staff turnover might be associated with higher mortality.²⁸

The interaction between service and organisational factors has not been examined. To our knowledge, no studies have examined the effect of implementation of service changes in different organisational contexts. For example, service changes might plausibly have less of an impact in health providers with an unhappy or constantly changing workforce.

In this study, we examined the relationship between service provision and suicide rates in all mental health services in England. Use of randomised controlled designs for this research would be extremely challenging. Therefore instead we used service developments as the basis of a natural experiment and opted for a descriptive design. The current study builds on earlier work¹⁸ by examining a wider range of service variables over a long period and for the first time considering the potential role of organisational variables. Although mental health care varies, many developed countries are dealing with similar issues, such as the move away from inpatient to community service provision, a focus on severe and enduring mental illness, ageing populations, and limited budgets.^{2,29,30} The findings of this study are therefore likely to have international relevance.

We had three main objectives. First, to examine the association between implementation of service changes and suicide. We hypothesised that service changes would be associated with improvements in patient safety as measured by a reduction in the rate of suicide. Second, to consider how wider organisational factors might affect suicide. We hypothesised that organisational factors such as staff and patient satisfaction and staff turnover would be associated with suicide rates. Third, to investigate whether the impact of service changes varied according to available measures of the organisational context in which they occurred. We hypothesised that changes would have less of an effect in mental health services that had markers of impaired organisational functioning.

Methods

Suicide data

Data were collected as part of the National Confidential Inquiry into Suicide and Homicide by People with Mental Illness (NCISH) for individuals aged 10 years and older who died by suicide in England between Jan 1, 1997, and Dec 31, 2012.³¹ NCISH collected data for those in contact with mental health services by starting with a complete national sample of suicide deaths, establishing which individuals had contact with mental health services within 12 months of death, and then sending the relevant clinicians detailed questionnaires to complete. Further detail on methods is available elsewhere.³² Case ascertainment and completion rates for questionnaires have been consistently high—95% and over. In the present study, we restricted ourselves to England. England is the largest of the UK’s constituent nations, and such an approach maximised the availability of consistent data whilst reducing the

policy and service heterogeneity that would have resulted from inclusion of Scotland, Wales, and Northern Ireland.

Suicide was defined as a death that received a suicide or open verdict at Coroner's inquest (ICD-10 Codes X60–X84; Y10–Y34, Y870, and Y872, excluding Y33.9). This definition is the conventional means of ascertaining suicide deaths for national UK statistics, clinical practice, and research. Most of the open verdict cases described previously are in fact suicide deaths and not including such deaths leads to a substantial underestimate of suicide.³³

Implementation of service changes: data collection from individual service providers

This study used methods developed in our previous research.¹⁸ For the present study, the medical directors of all National Health Service (NHS) mental health services in England (excluding the few private providers and regional forensic units) were asked to complete a service provision survey in January, 2012. The survey focused on the implementation of 16 key recommendations and service changes designed to improve safety (appendix). Nine of these recommendations were from our previous study¹⁸ and an additional eight were selected for their clinical and policy importance (eg, relating to the implementation of national clinical guidance). The survey items related to whether specific mental health service changes had been implemented and required a yes or no binary response. If the response was yes, an additional question asked for the month and year of implementation. Response rates were high (93%) but in the case of missing data items, we were able to supplement some data using earlier surveys. When the date of implementation was missing (6%), we imputed these data using the median date of implementation for the sample overall. During the study period, some services merged and some separated, so we combined responses for a few services. Where implementation had not been confirmed, this item was recorded as non-implementation. An additional question examined whether specialist services (eg, assertive outreach, early intervention, or crisis resolution teams) had been merged into generic community mental health services. We also requested data for the number of people in contact with that mental health service.

Data for the organisation and health of services: national data collection

To collect information on organisational factors, we used routinely available data sources, including annual reports from individual service providers, NHS staff and patient surveys,^{34,35} and national databases of hospital activity, such as the Mental Health and Learning Disabilities Data Set (MHLDDS).³⁶ Information was collected for the time period 2010–12 because of the availability of data. We collected information from each service provider in three main categories: staff data, patient data, and service

configuration data. The individual variables and data sources are listed in the appendix. We also collected data for the broader social context of the areas in which each of the mental health services were situated, including levels of unemployment and social deprivation using a standard national census-based measure—the Index of Multiple Deprivation Score.³⁷

Denominator data

To calculate rates of suicide, we obtained denominator data for the number of people in contact with mental health services from our survey data and the MHLDDS. The data collection method used by the MHLDDS changed in 2011 and 2012, resulting in approximately 24% more estimated contacts in 2011 than in 2010. We therefore adjusted the denominators based on the assumption of consistent data collection over time. For our before and after analysis, we carried forward earlier denominators to 2011 and 2012. For our cross-sectional analysis, we applied the 2011 denominator to 2010.

Statistical analysis

For services that had implemented individual service changes, we calculated the suicide rate before and after implementation. The number of years included in the post-implementation period varied from service to service and recommendation to recommendation. Some services were implemented early on in the time period and hence, had several post-implementation years of data. To ensure consistency across services we expressed rates per 10000 contacts with mental health services by per year. We calculated incidence rate ratios and 95% CIs using Poisson regression. We tested our models for over dispersion (ie, greater than expected variation in the outcome of interest). If this had been evident, we would have used negative binomial regression as an alternative analytical strategy, but in fact the Poisson assumptions held. We identified the five service changes associated with the biggest reductions in suicide rates.

Most services had implemented the changes by the end of the study period so comparison of suicide rates in non-implementing services was not possible, unlike in our previous study.¹⁸ Instead, to estimate the potential effect of decreasing background rates of suicide, we calculated incidence rate ratios comparing general population rates before and after implementation of the service changes. We hypothesised that any decrease in the general population rates would be smaller than the decrease in the clinical population, that is, the incidence rate ratios would be larger in the general population.

Next, we examined the association between the organisation of health services and suicide rates on combined data for the years 2010 to 2012 by calculating Spearman's correlations between individual staff, patient, and service factors and average suicide rates in England (per 10000 mental health service users). We also adjusted these correlations for deprivation and the rate of

See Online for appendix

	Rate before implementation (95% CI)	Rate after implementation (95% CI)	IRR (95% CI)	p value
Ward safety				
Removal of non-collapsible curtain rails	12.10 (11.84–12.36)	9.45 (9.26–9.65)	0.78 (0.76–0.81)	<0.0001
Removal of low lying ligature points	12.00 (11.75–12.25)	9.31 (9.11–9.51)	0.78 (0.75–0.80)	<0.0001
Community services				
Community health services include an AOT	12.58 (12.28–12.89)	9.78 (9.60–9.96)	0.78 (0.75–0.80)	<0.0001
Community health services include a CRHTT	12.98 (12.68–13.27)	9.46 (9.28–9.65)	0.73 (0.71–0.75)	<0.0001
Training				
Clinical staff receive training in the management of suicide risk	11.82 (11.58–12.07)	9.28 (9.08–9.48)	0.79 (0.76–0.81)	<0.0001
Policies				
Policy regarding response to inpatients who abscond	11.68 (11.48–11.89)	8.70 (8.47–8.94)	0.75 (0.72–0.77)	<0.0001
Policy on the follow-up of post-discharge patients	11.93 (11.70–12.17)	9.30 (9.10–9.51)	0.78 (0.76–0.80)	<0.0001
Policy on patients who are not taking medication as prescribed	11.75 (11.51–12.00)	9.17 (8.96–9.39)	0.78 (0.76–0.81)	<0.0001
Policy on the management of patients with dual diagnosis	11.84 (11.63–12.05)	8.71 (8.48–8.94)	0.74 (0.71–0.76)	<0.0001
Policy on information sharing with criminal justice agencies	11.86 (11.62–12.10)	9.23 (9.02–9.44)	0.78 (0.75–0.80)	<0.0001
Policy on multidisciplinary review information and sharing with families	12.38 (12.14–12.62)	8.87 (8.67–9.08)	0.72 (0.70–0.74)	<0.0001
Policy on the formal transfer of care from CAMHS to adult services	11.56 (11.36–11.76)	8.42 (8.13–8.72)	0.73 (0.70–0.76)	<0.0001
NICE guidance				
Mechanism to implement NICE guidelines	11.54 (11.34–11.75)	8.76 (8.52–8.99)	0.76 (0.74–0.78)	<0.0001
NICE self-harm guidelines implemented	11.61 (11.40–11.83)	8.72 (8.48–8.97)	0.75 (0.73–0.78)	<0.0001
NICE schizophrenia guidelines implemented	11.65 (11.43–11.87)	8.91 (8.66–9.17)	0.77 (0.74–0.79)	<0.0001
NICE depression guidelines implemented	11.78 (11.57–12.00)	8.32 (8.07–8.58)	0.71 (0.68–0.73)	<0.0001

IRR=incidence rate ratio. NICE=National Institute for Health and Care Excellence. AOT=assertive outreach team. CRHTT=crisis resolution and home treatment team. CAMHS=child and adolescent mental health services.

Table 1: Suicide rates (per 10 000 contacts with mental health services) before and after implementation of service changes or recommendations between 1997 and 2012

unemployment in the geographical areas covered by the mental health service providers to take into account wider social and contextual factors.

Finally, we examined the effect of the five service changes associated with the biggest reductions in suicide rate in different service contexts. Service context can be measured in various ways. To restrict the number of interaction tests done and avoid identification of potentially spurious associations, we were keen to restrict the number of contextual variables examined. We selected two variables as key markers of service context: non-medical staff turnover and overall rate of reported safety incidents. These factors were chosen because they were significantly correlated with suicide rates in our previous report.³⁴ Other factors could have been of potential importance, such as consultant staff turnover or staffing levels, staff or patient satisfaction, or patient complaints, but these showed either no or equivocal associations with suicide rates in previous work.^{14,34,38} Factors such as the use of compulsory detention, or medication prescribing might be positively correlated with suicide but are likely to be measures of underlying clinical need rather than organisational context.³⁴ We dichotomised mental health services on the basis of the median values of the selected variables (into groups of high and low proportions of staff turnover and high and low

rates of patient safety incidents per 10000 contacts) and examined decreases in suicide rate after implementation of the five service changes. Once again, we calculated incidence rate ratios and 95% CIs using Poisson regression and we also examined evidence of differences between groups by calculating interaction terms.

We used Stata/IC version 13.1 for Windows for all analyses.³⁹

Ethics approval

All data collected for this paper adhere to UK guidelines on conducting ethical research. The National Confidential Inquiry into Suicide and Homicide by People with Mental Illness received ethics approval from South Manchester Medical Research Ethics Committee, the North West Research Ethics Committee, the National Information Governance Board for Health and Social Care, the Patient Information Advisory Group, and approval under Section 251 of the Mental Health and Social Care Act.

Role of the funding source

This study was funded by the Healthcare Quality Improvement Partnership, and was carried out as part of the NCISH. The funders had no role in study design,

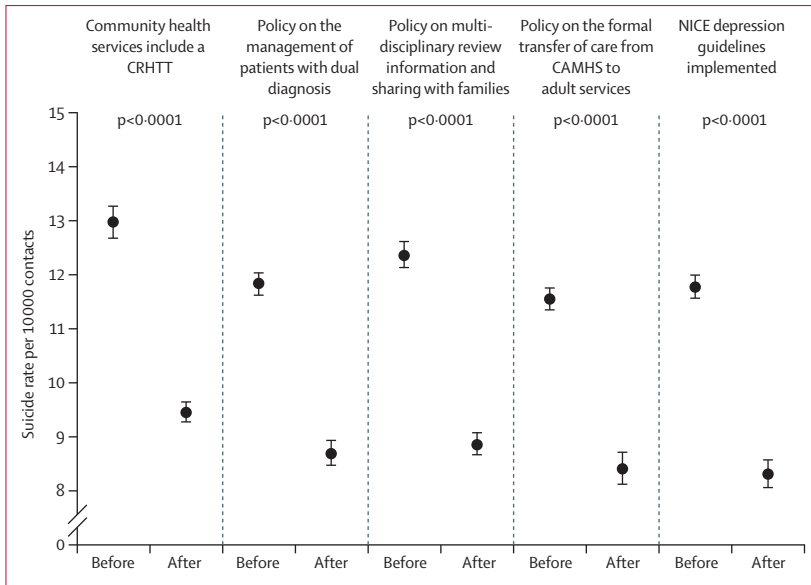


Figure 1: Suicide rate per 10000 contacts made with mental health services by patients before and after implementation of five recommendations with the biggest decrease in suicide
 Error bars show exact Poisson 95% CI. CAMHS=child and adolescent mental health services. CRHTT=crisis resolution or home treatment team. NICE=National Institute for Health and Care Excellence.

	N	Spearman's correlation (p value)
Staff		
Medical consultants (per 10 000 contacts)	61	0.33 (0.009)
Psychiatric nurses (per 10 000 contacts)	61	0.38 (0.003)
Staff sickness (%)	61	-0.12 (0.37)
Staff satisfaction: overall engagement score (score 1 to 5)	61	0.13 (0.33)
Staff satisfied with quality of work & care (score 1 to 5)	60	-0.11 (0.41)
Staff experiencing bullying or harassment from other staff (%)	61	0.07 (0.59)
Receiving job-relevant training, learning, or development in last 12 months (%)	61	0.15 (0.26)
Consultant staff turnover (%)	58	-0.02 (0.88)
Non-medical staff turnover (%)	58	0.34 (0.01)
Patients		
Written complaints (per 10 000 contacts)	60	0.12 (0.37)
Satisfied with overall care (%)	59	-0.06 (0.64)
Configuration		
Detained inpatients (per 10 000 contacts)	60	0.39 (0.002)
Mean length of hospital stay (days)	59	-0.02 (0.86)
Patient safety incidents (per 10 000 contacts)	55	0.46 (0.0004)
Bed occupancy (%)	60	-0.16 (0.23)

N=number of mental health services for which data for the given variable were available.

Table 2: Correlations between service features and suicide rate (per 10 000 contacts with mental health services)

data collection and analysis, decision to publish, or preparation of the manuscript.

Results

Between 1997 and 2012, 19248 patients died by suicide within 62 mental health services in England, representing

26% of all suicide deaths in England during this period. We obtained data from all services.

We examined 16 service changes in total. The average number of service changes implemented increased gradually, from 0.3 per service in 1998 to 14.6 in 2012. The median year of implementation ranged from 2002 to 2009 and the annual number of new implementations peaked in 2004 (n=112). By 2012, 58 services (94%) had implemented at least ten of the service changes and 34 (55%) had implemented all 16. The individual service changes that were most widely implemented by the end of the study period were removal of non-collapsible ligature points (97%), policies for response to inpatients who abscond (98%), and a mechanism to implement National Institute for Health and Clinical Excellence guidelines.

Table 1 shows the aggregate suicide rates before and after implementation across all 62 mental health providers. Implementation of all recommendations was associated with a significant decrease in the suicide rate. The five service changes associated with the largest proportionate decreases in suicide rate (figure 1) were implementation of National Institute for Health and Care Excellence depression guidelines, policies on reviews and information sharing with families after suicide, the availability of crisis resolution and home treatment teams, policies on the formal transfer of care from younger people's to adult services, and the management of patients with dual diagnosis (patients with drug or alcohol misuse as well as major mental illness).

When we compared incidence rate ratios before and after the median date of implementation of each service change for general population suicide rates, there was also evidence of a significant decrease in the overall rate of suicide. However, the reductions were smaller than in the clinical population; that is, the incidence rate ratios were larger for the general population (median incidence rate ratio 0.88, 95% CI 0.86–0.90) than for the patient population in this study (0.76, 0.73–0.78), and the distributions in the two groups differed significantly (Mann-Whitney $U=0$; $Z=-4.84$; $n_1=n_2=16$; $p<0.0001$ two-tailed).

With respect to the merging of specialist functions into generic mental health teams, numbers were small (only 16 services had merged specialist teams during the study period) but unlike a previous report,²³ we found no evidence that this merging was associated with an increased suicide risk; indeed, rates fell after implementation (aggregate suicide rate 11.94, 95% CI 11.64–12.24 before implementation vs 8.38, 7.73–9.06) after implementation.

Table 2 shows the cross-sectional correlations between a range of organisational variables and suicide rates in the 62 mental health services in England. Weak to moderate correlations were present with staffing levels, non-medical staff turnover, inpatients detained on a compulsory basis, and rate of patient safety incidents

	Services with high non-medical staff turnover IRR (95% CI)	Services with low non-medical staff turnover IRR (95% CI)	p value for interaction*	Services with high rate of patient safety incidents IRR (95% CI)	Services with low rate of patient safety incidents IRR (95% CI)	p value for interaction*
Community health services include a crisis resolution or home treatment team	0.77 (0.73–0.80)	0.68 (0.65–0.71)	<0.0001	0.68 (0.65–0.71)	0.80 (0.76–0.84)	<0.0001
Policy on the management of patients with dual diagnosis	0.77 (0.73–0.80)	0.69 (0.66–0.73)	0.002	0.68 (0.64–0.71)	0.80 (0.76–0.84)	<0.0001
Policy on multidisciplinary review information and sharing with families	0.78 (0.75–0.81)	0.64 (0.62–0.68)	<0.0001	0.66 (0.63–0.69)	0.78 (0.74–0.82)	<0.0001
Policy on the formal transfer of care from child and adolescent mental health services to adult services	0.78 (0.74–0.83)	0.64 (0.61–0.68)	<0.0001	0.66 (0.63–0.70)	0.79 (0.75–0.84)	<0.0001
NICE depression guidelines implemented	0.72 (0.68–0.75)	0.69 (0.66–0.73)	0.40	0.69 (0.66–0.73)	0.73 (0.69–0.77)	0.20

*Interaction between service implementation and organisation factor. Interaction tested by the Wald test. IRR=Incidence rate ratio. NICE=National Institute for Health and Care Excellence.

Table 3: IRR for suicide rates before and after service implementation stratified by high and low staff turnover and patient safety incidents

overall. These correlations remained largely unchanged after adjustment for area-based unemployment and deprivation score with the exception of non-medical staff turnover, for which the association was no longer statistically significant (adjusted correlation co-efficient 0.18, $p=0.2$). No evidence existed for associations between the patient suicide rate and other staff factors (including sickness levels, satisfaction, harassment, openness of incident reporting, training, patient satisfaction or complaints, length of stay, or bed occupancy).

Table 3 examines the effect of the five service changes associated with the biggest reductions in suicide rate (in the before-and-after analysis) in different service contexts. To avoid multiple testing, we restricted ourselves to two organisational factors potentially associated with suicide—non-medical staff turnover and rate of reported patient safety incidents overall.³⁸ We dichotomised services on the basis of the cross-sectional data (ie, high vs low staff turnover, high vs low rate of patient safety incidents).

All five service changes were associated with bigger reductions in suicide rate in organisations with low staff turnover, and for four (crisis resolution home treatment services, policy on review and information sharing with families, policies on transition of care from young people's services to adult services, and for patients with dual diagnosis) the interaction term indicated that the between-group differences were statistically significant (table 3). Figure 2 illustrates the reduction in suicide rate associated with introduction of a policy on review and information sharing after suicide in services with high and low staff turnover. Service changes were also associated with bigger reductions in suicide rates in organisations that had higher levels of reported safety incidents overall. Once again interaction terms were statistically significant for four of the five service changes (table 3).

Discussion

To our knowledge, this study is the first to consider mental health service provision, organisation of care, and

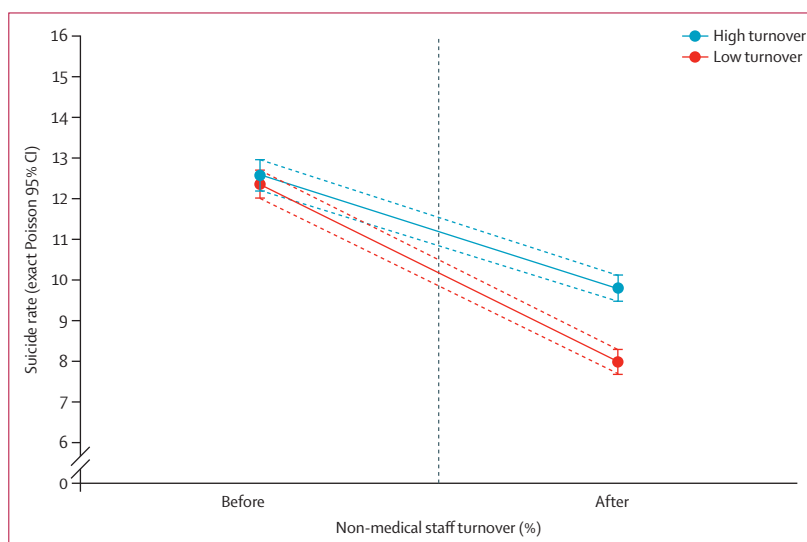


Figure 2: Suicide rates per 10 000 contacts made with mental health services by patients before and after implementation of the policy on multidisciplinary review information with families

Services divided into high and low non-medical staff turnover groups for comparison. Blue and red dotted lines indicate exact Poisson 95% CIs around the estimated suicide rates.

the interaction between delivery and contextual factors in relation to suicide rates in a national patient sample. Consistent with our hypotheses, we found that some service changes related to ward safety, community services, training, and the implementation of policy and guidance were associated with reduction in suicide rate after they had been introduced. It was not possible to establish the specific effect of individual service changes and these changes might have reflected general improvements in safety, but the reductions in the number of people to die from suicide in the clinical population appeared to be greater than those in the general population. We also found that some (but not all) wider organisational factors were related to suicide rates. Non-medical staff turnover and reporting of patient safety incidents were associated with suicide rates, but we found no association with other potentially important

characteristics such as staff sickness, or staff and patient satisfaction. Other factors that were associated with suicide rates on an aggregate level, such as medical and non-medical staffing and compulsory detention rates, probably reflected the underlying need and morbidity of the clinical populations. Interestingly, we did find some evidence that the effect of service changes varied according to organisational context. The changes might have had more effect in organisations that had low rates of staff turnover but high rates of overall event reporting.

We did this large national study over a 16 year period using a variety of data sources, but our findings should be interpreted cautiously. The main methodological weaknesses relate to the research design and the sources of data.

This study was observational therefore we cannot make causal inferences. We used before-and-after and ecological approaches to analysis. Variables such as the implementation of service changes and clinical guidance, adoption of policies, and staff turnover can be collected only at a service level and do not have readily available equivalents at the individual level. The limitations of aggregated, ecological data are well known. In this study, we do not know what services individual patients received. For example a patient treated in a service that had implemented rapid follow up after inpatient discharge, might not necessarily receive that follow-up. Other problems with ecological designs that apply to our study include incomplete adjustment for confounders, collinearity of explanatory variables, and absence of detailed individual data. Future studies that collect risk factors at an individual level as well as service level and use multilevel approaches to analysis could be potentially valuable.

The associations with suicide rates might well have been confounded by other unmeasured factors, such as changes in the case mix of catchment populations under the care of services (eg, sociodemographic factors, diagnostic case mix, and number with a history of suicidal behaviour). Other confounders could include overall levels of resource and organisational or service level changes. The cross-sectional correlations in particular should be interpreted cautiously. We were unable to identify the independent contribution of different service changes. Such changes are often introduced not as distinct interventions but as packages of service improvement. There were also potential shortcomings in the implementation data. We asked only whether changes were implemented or not. We did not have information on the timescales for implementation, or the extent and quality of the implementation. These weaknesses should certainly be addressed in future studies, perhaps by collection of process measures or by use of qualitative or anthropological study designs. Several previous studies have been purely ecological in design.^{16,17,21} We had the advantage in this study of a longitudinal component. Of course, a trial would be a

much stronger study, but a randomised national investigation of service changes with suicide as an outcome would not have been feasible. The numbers of patients required for such a study to be adequately powered are very large, even in high risk groups. For example, one review⁴⁰ estimated that a randomised control trial examining the effect of prevention initiatives on patients after discharge from psychiatric inpatient care would need to recruit more than 140 000 people. Other challenges include consent, recruitment, variations in treatment as usual, and how to take into account changing policy contexts during the duration of the trial. Alternatives such as phased national implementation or stepped wedge designs might be a helpful way to evaluate service changes.⁴¹ We carried out analyses without correction for multiple testing and therefore a risk exists of spurious associations (type 1 error). However, we were keen not to miss potentially important relationships between service variables and suicide and our analytical strategy was specified a priori.

We used national data sources and standard definitions of deaths by suicide, but many of our service variables were self-reported by providers and others were based on routine data not collected for research purposes. However, we think this factor is unlikely to have introduced a systematic error. In any case, overly optimistic reporting of service change or organisational factors for some settings might have the effect of weakening the power of the observed associations with suicide rates. Also, most services had implemented service changes by the end of the study period so no comparison group of non-implementing services was available in which to examine suicide rates. We attempted to address this issue by analysing changes in the general population suicide rate (before and after median years of implementation) but we acknowledge that this comparison is imperfect.

Our organisational variables related to a fairly recent time period (2010–12) to ensure consistency of reporting, but many of the service changes were introduced earlier. This time period could have affected our findings regarding the impact of service changes in different organisational contexts, but many of the organisational factors appeared to be fairly stable over time. The organisational context of these services is complex. We acknowledge that our selection of only two contextual variables for the third part of our study provides a limited exploration of the effect of service change in different environments. Our variables were selected on the basis of previous work but an investigation into which variables best capture organisational context in mental health settings should be a focus of future research.

We considered only England in this study because the clinical and policy context is slightly different in the other devolved nations of the UK. Nevertheless, we think our findings have relevance for mental health services internationally, particularly those in industrialised settings and those that focus on community mental

health provision.^{2,42} Indeed, some of the clinical aspects of suicide prevention reflect wider patient safety issues that are universal.

This study is consistent with earlier research by ourselves and others in showing that service delivery variables are associated with suicide rates, but it takes that work forward by examining a wide range of service changes. Additionally, we found that organisational factors might also be associated with suicide rates. Of course, we cannot definitively establish the nature of these relationships but causal links of some factors to suicide are plausible. For example, staff turnover could affect continuity of care, which could impact negatively on safety.²⁰ Conversely, high staff turnover might indicate wider problems within the organisation.⁴³ High numbers of safety incidents are sometimes thought to indicate an open reporting culture.⁴⁴ Although this might be the case, our study suggests that such incidents might be linked with the number of suicide deaths overall and be safety markers in their own right. Other factors such as higher staffing levels and greater use of compulsory powers were also linked to suicide rates, but these findings are likely to reflect the underlying characteristics of the catchment population (eg, high staffing levels or use of detention in services where the population has the greatest mental health need). We also found an interaction between service changes and organisational context. In services where staff turnover was high, the effect of service change on suicide rates was low. Previous studies have found that high staff turnover in mental health had a negative impact on the implementation of evidence-based practices.⁴⁵ Service change might also have had more of a positive effect in providers with higher levels of reported safety incidents. This outcome could indicate efficient reporting systems or a better learning culture but could also be a result of so-called regression to the mean in services with a greater number of safety incidents and higher suicide rates.

Clearly the implementation of service changes in mental health and their impact on suicide should be monitored on an ongoing basis. Initiatives to improve the collection of routine health data, in the UK and elsewhere,^{46–49} should contribute to more robust evaluation and various research methods could be used.⁵⁰ But in the meantime, what might our results mean for clinical practice? Our study suggests that service changes are important in determining safety but we could not establish which changes were the most important. This issue is a particular methodological challenge when multiple service changes are being implemented simultaneously and patient safety in general is improving. Our findings on the potentially beneficial effects of guideline implementation, information sharing, the availability of crisis and community services, and the effective management of substance misuse problems are consistent with previous research.^{16–18} System-wide change implemented across

the patient care pathway could be a key strategy to reduce suicide rates, but at least as important as the initiatives themselves, might be the organisational context in which they are introduced. We need to pay attention to both to make mental health services as safe as they can be.

Contributors

NK designed the study with input from SI and LA, led interpretation of the findings, drafted the paper, led subsequent revisions, and approved the final version. NK and LA are guarantors. LA, JS, and NK obtained funding for the National Confidential Inquiry. SI and members of the National Confidential Inquiry into Suicide and Homicide by People with Mental Illness research team were responsible for data acquisition. SI and DW were involved in the data design, ran the analyses, and helped to draft and revise the paper. SI, AB, CR, IMH, and KW collected data, coordinated the study data collection, and reviewed the paper. AM did the literature search. LA and JS helped to review and revise the paper. All authors approved the final version of the paper.

Declaration of interests

NK is supported by Manchester Mental Health and Social Care Trust. NK chaired the guideline development group for the 2012 National Institute for Health and Care Excellence (NICE) guidelines on the longer term management of self-harm and currently chairs the guideline development group for the NICE depression in adults guideline. LA chairs the National Suicide Prevention Strategy Advisory Group at the Department of Health (of which NK is also a member) and is a non-executive Director for the Care Quality Commission. All other authors declare no competing interests.

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