

1 **Effect of a two year national quality improvement program on surgical checklist**
2 **implementation**

3 **Effekt eines 2-jährigen nationalen Verbesserungsprogramms zur Einführung der**
4 **chirurgischen Checkliste.**

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7 Anna C Mascherek^{a*}, Paula Bezzola^a, Katrin Gehring^a, David LB Schwappach^{a, b*, †}

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9 ^a Swiss Patient Safety Foundation, Asylstrasse 77, 8032 Zurich, Switzerland

10 ^b Institute of Social and Preventive Medicine (ISPM), University of Bern, Finkenhubelweg 11,
11 3012 Bern, Switzerland

12 * Authors contributed equally; † Corresponding author;

13

14 Email addresses:

15 AM: mascherek@patientensicherheit.ch

16 KG: katrin.gehring@puk.zh.ch

17 PB: paula.bezzola@bluewin.ch

18 DS: schwappach@patientensicherheit.ch

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27 **Abstract**

28 Use of the surgical checklist in Switzerland is still incomplete and unsatisfactory. A national
29 improvement program was developed and conducted in Switzerland to implement and
30 improve the use of the surgical safety checklists. The aims of the implementation program
31 were to implement comprehensive and correct checklist use in participating hospitals in every
32 patient and in every surgical procedure; and to improve safety climate and teamwork as
33 important cultural context variables.

34 10 hospitals were selected for participation in the implementation program. A questionnaire
35 assessing use, knowledge, and attitudes towards the checklist and the Safety Climate Survey
36 were conducted at two measurement occasions each in October/November 2013 and
37 January/February 2015. Significant increases emerged for frequency of checklist use ($F_{(1,1001)}$
38 $= 340.9, p < 0.001$), satisfaction ($F_{(1,1232)} = 25.6, p < 0.001$), and knowledge ($F_{(1,1294)} = 184.5,$
39 $p < 0.001$). While significant differences in norms ($F_{(1,1284)} = 17.9, p < 0.001$) and intentions
40 ($F_{(1,1284)} = 7.8, p < 0.01$) were observed, this was not the case for attitudes ($F_{(1,1283)} = .8, n.s.$)
41 and acceptances ($F_{(1,1284)} = 0.1, n.s.$). Significant differences for safety climate and teamwork
42 emerged in the present study ($F_{(1,3555)} = 11.8, p < 0.001$ and $F_{(1,3554)} = 24.6, p < 0.001,$
43 respectively). However, although statistical significance was reached, effects are very small
44 and practical relevance is thus questionable. The results of the present study suggest that the
45 quality improvement program conducted by the Swiss Patient Safety Foundation in 10
46 hospitals led to successful checklist implementation. The strongest effects were seen in
47 aspects concerning behaviour and knowledge specifically related to checklist use. Less impact
48 was achieved on general cultural variables safety climate and teamwork. However, as a trend
49 was observable, these variables may simply need more time in order to change substantially.

50 **Keywords:** Surgical safety checklist, implementation program Switzerland, Safety Climate,
51 Attitudes, Survey data.

52

53 **Abstract**

54 Die Anwendung der chirurgischen Checkliste ist in der Schweiz heute noch immer nicht
55 zufriedenstellend. Ein nationales Verbesserungsprogramm wurde entwickelt und umgesetzt,
56 um die chirurgische Checkliste einzuführen und ihre Anwendung zu verbessern. Ziele des
57 Verbesserungsprogramms waren erstens die umfassende und richtige Anwendung der
58 Checkliste in den teilnehmenden Spitälern bei jedem Patienten und jedem chirurgischen
59 Eingriff und zweitens die Verbesserung des Sicherheitsklimas und der Teamzusammenarbeit
60 als wichtige Aspekte der Betriebskultur. 10 Spitäler wurden für die Teilnahme am Programm
61 ausgewählt. Zu zwei Erhebungszeitpunkten (Oktober/November 2013 und Januar/Februar
62 2015) wurden mit einem Fragebogen Anwendung, Wissen und Einstellungen gegenüber der
63 chirurgischen Checkliste sowie Sicherheitsklima und Teamzusammenarbeit gemessen. Es
64 zeigten sich signifikante Veränderungen für die Häufigkeit der Anwendung ($F_{(1,1001)} = 340.9$,
65 $p < 0.001$), Zufriedenheit mit der Anwendung ($F_{(1,1232)} = 25.6$, $p < 0.001$) und Wissen ($F_{(1,1294)} =$
66 184.5 , $p < 0.001$). Signifikante Unterschiede zeigten sich auch für Normen ($F_{(1,1284)} = 17.9$,
67 $p < 0.001$) und Intentionen ($F_{(1,1284)} = 7.8$, $p < 0.01$), allerdings nicht für Einstellungen ($F_{(1,1283)} =$
68 $.8$, *n.s.*) und Akzeptanz ($F_{(1,1284)} = 0.1$, *n.s.*). Auch Sicherheitsklima und Teamzusammenarbeit
69 veränderten sich signifikant ($F_{(1,3555)} = 11.8$, $p < 0.001$ und $F_{(1,3554)} = 24.6$, $p < 0.001$), die
70 geringen Effektstärken deuten aber auf eine geringe praktische Relevanz dieser Unterschiede
71 hin. Die Ergebnisse der vorliegenden Studie zeigen, dass das von der Stiftung
72 Patientensicherheit Schweiz durchgeführte Verbesserungsprogramm eine erfolgreiche
73 Einführung der chirurgischen Checkliste bewirkt hat. Die stärksten Effekte zeigten sich bei
74 konkretem Verhalten und Wissen in direkter Verbindung zur Anwendung der chirurgischen
75 Checkliste. Geringe Unterschiede zeigten sich in den allgemeineren Kulturvariablen
76 Sicherheitsklima und Teamzusammenarbeit. Der Trend deutet darauf hin, dass eine
77 Veränderung in diesen Variablen mehr Zeit braucht.

78 **Schlüsselwörter:** chirurgische Checkliste, Implementierungsprogramm in der Schweiz,
79 Sicherheitsklima, Einstellungen, Fragebogenerhebung.

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82 **1. Introduction**

83 The WHO estimated that more than 234 million major surgical procedures are undertaken
84 every year worldwide [1]. In high-expenditure countries, the mean surgical rate is 11'110 per
85 100'000 population. Research suggests that 3-16% of patients undergoing surgery will suffer
86 adverse events, with a considerable fraction of these events deemed preventable [2-4].

87 Surgery has also been identified as one major predictor of patient reported hospital-acquired
88 infections [5]. Given the high volume of surgery, these figures make improvements in safety
89 of surgery a global public health issue. During the last years the WHO surgical safety
90 checklist has emerged as a powerful intervention to increase safety in surgery. The checklist
91 has become one of the most strongly recommended "single-intervention" safeguards
92 worldwide [6]. The checklist has been proven to be an effective intervention to reduce
93 morbidity and mortality in surgical procedures [7]. However, recent evidence also suggests
94 that simply making the surgical checklist mandatory by policy-makers does not necessarily
95 improve surgical outcomes [8-10]. Research revealed that in order to be effective, the surgical
96 safety checklist must be used and applied correctly, completely and in all patients [10-12].

97 While the checklist itself rather serves as a cognitive aid, the introduction of the checklist is a
98 complex team intervention making its sustainable implementation challenging. The checklist
99 is more than a ticking box exercise and requires change and the willingness to change on
100 different levels within an organization. For example, team communication behaviours and
101 information sharing among team members during intraoperative phases have been associated
102 with decreased mortality and major complications in surgery [13]. But interaction and
103 communication within surgical teams require acceptance, acknowledgement and a joint

104 understanding of the different roles of co-workers, in particular, across the professions. A
105 recent systematic review confirmed that operating room teamwork and communication can be
106 improved by checklist use. This may be one mechanism through which patient outcomes are
107 improved with checklist implementation [14,15].

108 Checklist use in Switzerland is still incomplete and unsatisfactory. In a recent study,
109 Mascherek et al. [16] found that about 80% of the study participants use a surgical checklist
110 on an everyday level. Only 61% of the nursing staff and 72% percent of the doctoral staff
111 were satisfied with the use of the checklist, indicating that the quality of use was less than
112 perfect. Several European countries already work together in the High 5s project to improve
113 checklist use in hospitals [17]. However, because Switzerland is not part of the European
114 program, a national improvement program was developed and conducted in Switzerland to
115 implement and improve the use of the surgical safety checklists. The program was developed
116 based on implementation research, international quality improvement programs, and expert
117 opinion. Leadership, inter-professional project teams, local champions, training, and
118 education were substantial parts of the implementation process.

119 The aims of the implementation program were twofold: first, to implement comprehensive
120 and correct checklist use in participating hospitals in every patient and in every surgical
121 procedure; and second, to improve safety climate and teamwork as important cultural context
122 variables. The program was accompanied by extensive evaluation on different levels. In a pre-
123 post intervention design, safety climate and staff attitudes were assessed at two measurement
124 occasions.

125 In the present paper we provide an overview of the results of the two-year national
126 improvement program. We describe changes in checklist use, knowledge and attitudes
127 towards checklists, and changes in safety climate and teamwork between measurement points
128 on group level

129

130 **2. Method**

131 2.1. Design

132 The national quality improvement program was developed and conducted by the Swiss
133 Patient Safety Foundation between 2012 and 2015 (for a detailed study protocol see Kobler et
134 al., 2014 [18]).

135 The program was designed to compromise 2 axes to mutually affect one another. On axis 1, a
136 national campaign was conducted between 2012 and 2015 to promote patient safety in general
137 and the use of the WHO surgical checklist in particular. Axis 2 consisted of a specific
138 improvement intervention with 10 participating hospitals. Hospitals were recruited via a
139 national open tender. All Swiss acute-care hospitals could apply for participation.

140 Participation was promoted as prestigious. Application was connected to the evaluation
141 program from which the data for the present study originates. No financial compensation was
142 offered, but participating hospitals had to pay an attendance fee of CHF 6000. In total, 32
143 hospitals applied for participation from all areas of Switzerland. 10 out of the 32 applicants
144 were selected for participation. Criteria for hospital selection were hospital size, hospital
145 speciality, geographical region in Switzerland, explicit commitment from senior surgeons and
146 anaesthetists, and whether or not they had already implemented any surgical checklist in their
147 operating room–routine (OR).

148 The improvement program was scheduled between summer 2013 and summer 2015.

149 Hospitals were contractually bound to implement the checklist and execute mandatory
150 activities during the program such as training of checklist use, education of staff, and local
151 adaptation of checklist. Also, explicit support by leadership, support by local champions, and
152 establishing a cross-professional team were mandatory components of the program.

153 Additionally, to facilitate exchange and learning between hospitals, 4 mandatory workshops
154 were held during the 2 years of program execution.

155 Data in the present study were collected with two separate questionnaire instruments during
156 the program at two time points each. The time between data collections was 15 months. Print
157 versions of the surveys were sent to hospitals and locally distributed. Surveys were provided
158 in German and French. The survey sample consisted of all members of the Operating Room
159 (OR) teams of the participating hospitals (doctors, nurses, scrub nurses, surgical technicians,
160 and attendants for surgical positioning). The sample for the assessment of safety climate and
161 teamwork additionally included ward staff (doctors, nurses, nursing assistants, and further
162 professionals who were subsumed under “others” involved in the pre- and postoperative care
163 of surgical patients). Subjects were invited to participate by the hospitals’ project teams and
164 repeatedly reminded throughout the data-collecting period. As the study was conducted as
165 part of a quality improvement project, study design and data collection did not require
166 approval of an ethical committee in Switzerland referring to Article 1 and 2 of the Federal Act
167 on Research involving Human Beings (Human Research Act, HRA) [19].

168

169 2.2. Survey instruments

170 2.2.1. Use, knowledge, and attitudes towards the checklist (“Attitudes survey”)

171 The first survey was developed to assess use of, knowledge of and attitudes towards the
172 surgical checklist. It was developed on the basis of extensive review of the literature and own
173 pilot studies. The survey consisted of three conceptual parts. The first part referred to the
174 general use of surgical checklists in the OR (e.g., “which of the following checklists do you
175 use?”) and relative frequency of use (rated on a 0-100% scale subdivided into 6 categories).
176 Satisfaction with using the checklist was also assessed in part one and rated on a 5-point-
177 Likert-scale ranging from “very unsatisfied” to “very satisfied”. General attitudes towards the
178 use of the checklist in clinical practice were assessed in a semantic differential. The semantic
179 differential acts as “barometer” and addresses the perceived atmosphere of checklist
180 implementation. The differential used six pairs of adjectives with opposing meaning to

181 describe checklist use. Paired adjectives were “easy-difficult”, “pleasant-unpleasant”,
182 “familiar-unfamiliar”, “important-unimportant”, and “good for staff-bad for staff”, “good for
183 patients-bad for patients”. The continuum consisted of a 7-point-scale with “7” anchoring a
184 positive attitude and “1” a negative attitude.

185 In the second part, knowledge of the WHO-checklist was assessed. Subjects rated their
186 subjective knowledge of the checklist on a 5-point-Likert-scale from “very bad” to “very
187 good”. In the third part, attitudes towards, acceptance of, norms, and intention to use the
188 checklist were assessed. Norms (e.g. “Surgeons look down upon checklist use”) were
189 measured with 4 items, acceptance (e.g. “The checklist is evidence-based.”) with 5 items,
190 attitudes (e.g. “Checklist use enhances paying attention to patient safety”) with 7 items, and
191 intentions with (e.g. “It is my plan to carefully mind the use of the checklist”) with 6 items.
192 All items were rated on a 7-point-Likert-scale ranging from “do not agree at all” to
193 “completely agree” (for the wording of all survey-items see Appendix A). High scores
194 indicate a positive evaluation of the checklist. Four items had to be reverse coded for data
195 analyses. The survey was pre-tested with individuals from all professions and languages.

196

197 2.2.2. Safety Climate Survey

198 As second questionnaire the Safety Climate Survey was applied [20,21]. The original version
199 of the Safety Climate Survey was translated by a professional translator from English to
200 German and back-translated to English by a second translator. Differences in translation and
201 back-translation were discussed and resolved by the research team. The survey was also
202 translated to French and proofread by bilingual researchers in French (for the wording of all
203 survey-items see Appendix B). Two versions (“OR” and “ward”) were developed differing in
204 the wording of single items referring to the specific working area. Details on survey
205 development are provided elsewhere [22]. The questionnaire consisted of the 19 items of the

206 Safety Climate Survey and was rated on a 5-point Likert-scale from 1 = “disagree strongly” to
207 5 = “agree strongly”. At the end of the survey, socio-demographic variables were assessed.

208

209 **2.3. Data analyses**

210 Individuals who answered less than 60% of the items were dropped from analysis.

211 ANOVA was conducted to test for differences between time points on different variables. The
212 Scheffé correction was applied to significance tests to account for multiple comparisons and
213 correct for cumulative type I error. Effect sizes were calculated with Cohen’s *d*. According to
214 convention, 0.2 is considered a small, 0.5 a medium, and 0.8 a large effect [23]. Although for
215 some of the measures the assumption of homoscedasticity was violated, we conducted one-
216 way ANOVA as the sample was large enough and balanced. ANOVA is a robust estimator
217 against violations of homoscedasticity in large, balanced samples [24]. Cluster effects were
218 not considered when analysing the data. All analyses were conducted using STATA v13.1
219 [25].

220

221 **3. Results**

222 3.1. Sample

223 742 individuals completed the attitudes-questionnaire at time-point 1 (T1) and 660 at time-
224 point 2 (T2). 1966 individuals completed the safety-climate-questionnaire at T1 and 1604 at
225 T2. 217 individuals only answered the attitudes -questionnaire, 1441 individuals only
226 answered the safety-climate-questionnaire, and 525 individuals returned both questionnaires
227 at T1. The corresponding figures for T2 were 142, 1086, and 518, respectively. This equals
228 response rates of 37.9% at T1 and 31.9% at T2 for the attitudes -questionnaire and 42.7% at
229 T1 and 33.3% at T2 for the safety-climate-questionnaire.

230 Sample characteristics separated by time-points are presented in table 1. Although some of the
231 characteristics differ significantly between time-points, significance is due to the large sample

232 size rather than to practically relevant differences. Samples are hence to be considered as
233 being comparable between time points with respect to socio-demographic variables.

234

235 3.2. Means at T1

236 Means of the variables under study at T1 and T2 are presented in table 2. The mean for
237 frequency of use was $M = 3.5$ ($SD = 2.2$), for satisfaction with use $M = 3.4$ ($SD = 1.1$), and for
238 subjective knowledge $M = 3.2$ ($SD = 1.2$), hence, in the mid-range of the scale. Means for
239 safety climate ($M = 3.8$, $SD = 0.5$) and teamwork ($M = 3.9$, $SD = 0.7$) were in the mid-range
240 of the scale as well. For norms, attitudes, acceptance, and intentions means were $M = 5.9$ (SD
241 $= 1.0$), $M = 6.0$ ($SD = 1.0$), $M = 6.1$ ($SD = 0.9$), and $M = 6.2$ ($SD = 1.0$), respectively. On a 7-
242 point scale, these values are already very high, hence, imposing the possibility of ceiling
243 effects at T2. For norms, the highest score on the scale accounted for 31% of the answers.
244 This applied to 34% in attitudes, 40% in acceptance, and even 50% in intentions, emphasizing
245 the possibility of ceiling effects at T2. Means for the paired adjectives “easy-difficult” ($M =$
246 5.9 , $SD = 1.3$), “pleasant-unpleasant” ($M = 5.4$, $SD = 1.4$), “familiar-unfamiliar” ($M = 5.3$, SD
247 $= 1.8$), “important-unimportant” ($M = 6.4$, $SD = 1.2$), “good for staff-bad for staff” ($M = 6.2$,
248 $SD = 1.1$), “good for patients-bad for patients” ($M = 6.5$, $SD = 0.9$) were also already high at
249 T1. High scores accounted for a considerable amount of answers in all of the paired
250 adjectives, with the least of 26% in “pleasant-unpleasant” (easy-difficult” 43%, “pleasant-
251 unpleasant” 26%, “familiar-unfamiliar” 32%, “important-unimportant” 67%, “good for staff-
252 bad for staff” 57%, “good for patients-bad for patients” 73%), hence, again, imposing the
253 possibility of ceiling effects at T2.

254

255 3.3. Mean Differences

256 Checklist use and knowledge

257 Significant differences between time points concerning frequency of checklist use emerged,
258 indicating that the checklist was used more often at the end of the program ($F_{(1,1001)} = 340.9, p$
259 <0.001). The difference in use denotes a large effect; hence, the increase can also be
260 interpreted as being of practical significance. Satisfaction with use was also significantly
261 higher at T2 ($F_{(1,1232)} = 25.6, p < 0.001$). However, effect size for this difference was small,
262 indicating that the difference in satisfaction was less pronounced. Results for knowledge also
263 show higher values at T2 ($F_{(1,1294)} = 184.5, p < 0.001$). Effect size for this difference is large,
264 indicating that differences in subjective knowledge are of practical significance. Items of the
265 semantic differential describe the perceived usability and practical significance of the
266 checklist for staff and patients. Results for these items were mixed. Significant differences
267 emerged only on the dimensions “easy-difficult” and “familiar-unfamiliar” with $F_{(1,1220)} = 46,$
268 $p < 0.001$ and $F_{(1,1215)} = 100.5, p < 0.001$, respectively. On the remaining dimensions (“pleasant-
269 unpleasant”, “important-unimportant”, “good for staff-bad for staff”, and “good for patients-
270 bad for patients”) no significant differences emerged. Data are presented in table 2.

271

272 3.4. Attitudes towards checklist use

273 Effects of the program were also assessed for personal attitudes, norms and intention to use
274 the checklist. The scales reflect an individual’s personal attitude towards the checklist, his/her
275 intention to use the checklist and his/her perception of checklist use as being normative.
276 Results were mixed. While significant differences in norms ($F_{(1,1284)} = 17.9, p < 0.001$) and
277 intentions ($F_{(1,1284)} = 7.8, p < 0.01$) were observed, this was not the case for attitudes ($F_{(1,1283)} =$
278 $.8, n.s.$) and acceptances ($F_{(1,1284)} = 0.1, n.s.$). However, effect sizes for differences in norms
279 and intentions were small, indicating limited practical relevance. Data are presented in table 2.

280

281 3.5. Safety climate and teamwork

282 Significant differences for safety climate and teamwork emerged in the present study ($F_{(1,3555)}$
283 = 11.8, $p < 0.001$ and $F_{(1,3554)} = 24.6$, $p < 0.001$, respectively). However, although statistical
284 significance was reached, effects are very small and practical relevance is thus questionable.
285 Means are presented in table 2.

286

287 **4. Discussion**

288 The goal of the present study was to provide a broad overview of differences on various
289 dimensions related to surgical checklist implementation in Switzerland. Different aspects
290 relevant for implementation programs were addressed. Differences were most pronounced in
291 a group of variables that mainly reflect practical aspects of checklist use. The largest
292 differences emerged for frequency of checklist use, familiarity, and knowledge. These
293 variables directly reflect a changed routine of checklist use. Staff of participating hospitals
294 was explicitly educated about objectives and aims of the checklist. Also, checklist use was
295 made mandatory in the treatment of all patients undergoing surgery during the study period.
296 Increase in usage may be reflected in greater familiarity. This is supported by an increase in
297 the “ease of use” rating of the checklist. Although no causal inferences are warranted, it seems
298 reasonable that differences in those variables are a result of the activities during the
299 implementation program which mainly focused on correct checklist use. Staff, for example,
300 had to participate in trainings outside the OR before checklist implementation. Results
301 indicate that this aim was achieved including side-effects on familiarity and ease of use.
302 A second set of variables assessed attitudes, norms, intentions, and acceptance of checklist
303 use. While significant effects for norms and intentions emerged, no significant differences
304 were observed in acceptance and attitude. Effects that were found were of small to medium
305 size. It seems reasonable that every-day-checklist-use, education of staff and changed hospital
306 policies strengthened norms perceived by staff. At least superficially, not using the checklist
307 in surgery is more and more perceived as unprofessional behaviour. However, no differences

308 for acceptance of the checklist as a relevant tool to improve patient safety were observed.
309 Two explanations are possible. First, no intervention was tailored to explicitly affect attitudes,
310 as the program explicitly focused on the practical implementation of the checklist. Hence,
311 attitudes simply remained unaffected by the program... Second, as scores on attitudes were
312 already high at T1 with a considerably proportion of the sample scoring at the upper boundary
313 of the scale, the results may reflect ceiling effects. High levels of acceptance have also been
314 reported by Rothmund et al in Germany [26]. In their study, checklists were acknowledged as
315 useful tool, however, leaving room for improvement in daily practice. This result resembles
316 the pattern found in Switzerland before the national improvement program, underlining the
317 interpretation of the checklist being an accepted patient safety tool even before the
318 intervention. The results suggest that the interventions mainly worked on closing the gap
319 between what is considered a relevant tool in theory and what is actually applied in the field.
320 Impact of the program mainly affected behavioural aspects and knowledge of checklist use on
321 daily basis. One may conclude that the main difference after the program was the shift from
322 “theory to practice”. This interpretation is supported by several personal experiences and
323 feedback from project managers during the program.

324 A second aim of the quality improvement study was to improve overall safety climate and
325 teamwork in the course of checklist implementation and use. Although significant differences
326 emerged, effect sizes were very small. As sample size was large, the differences found in the
327 present study must be interpreted as being of little practical relevance. However, a trend
328 emerged, pointing into the targeted direction. Stronger effects might be observable on item
329 level. The more detailed analysis of the data from T1 revealed stronger mean difference on
330 item level than on scale level [27]. However, as hospital organizational culture needs time to
331 change, the interval between measurements in our study might simply have been too short to
332 exhibit substantial differences on scale level.

333 This study has several limitations. First, no clinical outcome measures were assessed, hence,
334 direct effects on adverse events could not be observed. However, as compliance with checklist
335 use was high, the inference seems justified that the program not only led to comprehensive
336 checklist use but, as a consequence, also improved patient safety in surgery. A second
337 limitation lies in the sampling itself. Although study requirements specifically defined sample
338 composition, this was only controlled for by the local project manager. Hence, sample
339 composition might have varied between sites. Finally, only 10 hospitals participated in the
340 program. Although hospital selection took various aspects into account, generalizability of the
341 results is limited. This is especially the case as no causal inferences can be made from the
342 results of the present study. If, and if so which aspect of the intervention actually caused the
343 differences on the measures between time points remains unknown. Strong experimental or
344 RCT-studies are needed in order to extract causal factors underlying achieved differences in
345 large quality improvement programs.

346

347

348 **5. Conclusion**

349 The results of the present study suggest that the quality improvement program conducted by
350 the Swiss Patient Safety Foundation in 10 hospitals led to successful checklist
351 implementation. The strongest effects were seen in aspects concerning behaviour and
352 knowledge specifically related to checklist use. Less impact was achieved on the general
353 cultural variables safety climate and teamwork. However, as a trend was observable, these
354 variables may simply need more time in order to change substantially. Taken together, the
355 results of the present study show that the program was suitable for successful implementation
356 of comprehensive checklist use in Swiss hospitals.

357

358 **Table 1. Sample characteristics** ($N_{total}=3929$) N for subsamples are: $n_{t1attitude} = 742$; $n_{t2attitude}$
 359 $= 660$; $n_{t1safetyclimate} = 1966$; $n_{t2safetyclimate} = 1604$. Because some individuals answered both
 360 questionnaires the sum of the subsamples is larger than the total n per time-point. Data not
 361 adding up to 100% are due to missing values

Characteristic†	T1		T2	
	$n_{t1} = 2183$	%	$n_{t2} = 1746$	%
Survey language				
German	1460	66.9	1162	66.6
French	723	33.1	584	33.4
Gender				
Male	622	29.1	505	29.6
Female	1515	70.9	1203	70.4
Mean age in years*	38.9 (SD: 11.3)		38.1 (SD: 11.1)	
Profession				
Physician	573	27.3	502	30.1
Nurse	1176	56.1	913	54.8
Other	347	16.6	252	15.1
Managerial function				
Yes	511	24.3	385	22.9
No	1587	75.6	1295	77
Years of professional experience*				
0 - 2	286	13.4	296	17.2
2 - 5	387	18.1	317	18.5
5 - 10	427	20	317	18.5
10 - 20	541	25.3	426	24.8
More than 20	490	23	361	21
Hours of direct patient care per week*				
0	295	14	214	12.7
0-8	328	15.5	237	14.1
8-16	259	12.3	208	12.3
16-24	295	14	230	13.7
24-32	299	14.1	240	14.2
32-40	355	16.8	298	17.7
More than 40	276	13.1	250	14.8

362 † Note: Characteristics marked with “*” differ significantly between time-points on $p < .05$.

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Table 2. Differences in mean scores of assessed constructs between time points

	Mean _{T1} (SD)	n _{T1}	Mean _{T2} (SD)	n _{T2}	Effect sizes*	p-value
Frequency of use	3.5 (2.2)	491	5.8 (.80)	512	1.2	<0.001
Satisfaction with use	3.4 (1.1)	419	3.8 (1.1)	507	0.3	<0.001
Semantic differential						
easy-difficult†	5.9 (1.3)	584	6.3 (1.0)	638	0.4	<0.001
pleasant-unpleasant†	5.4 (1.4)	579	5.8 (1.4)	635		n.s.
familiar-unfamiliar†	5.3 (1.8)	580	6.1 (1.1)	637	0.6	<0.001
important-unimportant†	6.4 (1.2)	594	6.5 (1.0)	643		n.s.
good for staff-bad for staff†	6.2 (1.1)	595	6.3 (1.1)	641		n.s.
good for patients-bad for patients†	6.5 (.9)	591	6.6 (.9)	641		n.s.
Subjective knowledge	3.2 (1.2)	647	4.1 (1.1)	649	0.8	<0.001
Norms	5.9 (1.0)	637	6.1 (.8)	649	0.3	<0.001
Attitude	6.0 (1.0)	636	6.0 (1.0)	649		n.s.
Acceptance	6.1 (.9)	637	6.2 (.9)	649		n.s.
Intentions	6.2 (1.0)	637	6.4 (.9)	649	0.2	<0.001
Safety Climate	3.8 (.5)	1957	3.9 (.6)	1600	0.12	0.001
Teamwork	3.9 (.7)	1956	4.0 (.7)	1600	0.12	<0.001

367 *Note:* T1 = time point 1, T2 = time point 2, *we report Cohen's *d* for differences between
368 time points. †higher values indicate more positive evaluation

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373 **Competing interests**

374 The authors declare that they have no competing interests.

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376 **Authors' contribution**

377 DS and PB designed the study. AM and KG substantially contributed to design and
378 conception. AM, KG, DS developed the survey. AM conducted statistical analyses. AM and
379 DS drafted the manuscript. KG and PB revised the manuscript critically for important
380 intellectual content. All authors read and approved the final manuscript.

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483 **Appendix A.** Wording items of Attitude-survey (items translated from the German original)

Item No.	Item
V04	Checklist use facilitates speaking up in the OR. (attitude)
V06	Checklist use is far too time-consuming. (attitude)
V09	Checklist use decreases adverse events. (attitude)
V13	Checklist use hinders the flow of information among OR-team members. (attitude)
V19	Checklist use enhances paying attention to patient safety. (attitude)
V20*	Checklist use interferes with my tasks. (attitude)
V22*	A well-functioning OR-team does not need a checklist. (attitude)
V15	Surgeons look down upon checklist use. (norms)
V18	My colleagues take checklist use serious. (norms)
V23	My supervisor promotes checklist use. (norms)
V24	I am expected to use the checklist seriously. (norms)
V07	I will promote checklist use. (intentions)
V08	I will support my colleagues with using the checklist. (intentions)
V10	Next time I am up to decide, I will apply the checklist. (intentions)
V11	It is my plan to carefully mind the use of the checklist. (intentions)
V16	I want the checklist to be used with every patient. (intentions)
V25†	It is my duty to correctly use the checklist. (intentions)
V26	The checklist is not necessary. (acceptance)
V14	The checklist is a well-designed tool to enhance patient safety (acceptance)
V12	If I had to have an operation, I would want the checklist to be applied. (acceptance)
V02	The checklist is not more than a ticking-exercise. (acceptance)
V01	The checklist is evidence-based. (acceptance)

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491 **Appendix B.** Items of the Safety Climate Survey (SCS) and Teamwork (TW)

Item No.	Item
V1	The culture of this clinical area makes it easy to learn from the mistakes of others. (SCS)
V2	Medical errors** are handled appropriately in this clinical area. (SCS) ** <i>Medical error is defined as any mistake in the delivery of care, by any healthcare professional, regardless of outcome.</i>
V3	The senior leaders in my hospital listen to me and care about my concerns. (SCS)
V4	The physician and nurse leaders in my area listen to me and care about my concerns. (SCS)
V5	Leadership is driving us to be a safety- centred institution. (SCS)
V6	My suggestions about safety would be acted upon if I expressed them to management. (SCS)
V7	Management/leadership does not knowingly compromise safety concerns for productivity. (SCS)
V8	I am encouraged by my colleagues to report any safety concerns I may have. (SCS)
V9	I know the proper channels to direct questions regarding patient safety. (SCS)
V10	I receive appropriate feedback about my performance. (SCS)
V11	I would feel safe being treated here as a patient. (SCS)
V12	Briefing personnel before the start of a shift (i.e., to plan for possible contingencies) is an important part of patient safety. (SCS)
V13	Briefings are common here. (SCS)
V14	I am satisfied with the availability of clinical leadership.
V14a	Physician(SCS)
V14b	Nursing
V14c	Pharmacy
V15	This institution is doing more for patient safety now than it did one year ago. (SCS)
V16	I believe that most adverse events occur as a result of multiple system failures and are not attributable to one individual's actions. (SCS)
V17	The personnel in this clinical area take responsibility for patient safety. (SCS)
V18	Personnel frequently disregard rules or guidelines that are established for this clinical area. (SCS)
V19	Patient safety is constantly reinforced as the priority in this clinical area. (SCS)
V20	Input from nursing staff is well-received in my area of work. (TW)
V21	Conflicts in my area of work are solved appropriately. (that is the focus is not on <i>who</i> is right but on <i>what</i> is best for the patient) (TW)
V22	I receive the support I need from my colleagues to adequately take care of the

patients. (TW)

V23 It is easy for staff to ask questions in case of lack of knowledge. (TW)

V24 It is difficult in my area of work to address problems concerning patient care.
(TW)

V25 Doctors and Nurses work together well as an experienced team. (TW)

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