RESEARCH REPORT

Reducing problematic alcohol use in employees: economic evaluation of guided and unguided web-based interventions alongside a three-arm randomized controlled trial

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Abstract

Aims: To perform an economic evaluation of guided and unguided internet-based interventions to reduce problematic alcohol consumption in employees compared with a waiting-list control condition (WLC) with unrestricted access to treatment-as-usual.

Design: A cost-effectiveness analysis (CEA) and cost–utility analysis (CUA) from a societal and a cost–benefit analysis from the employer's perspective with a 6-month time horizon.

Setting: Open recruitment in the German working population.

Participants: Employees (178 males, 256 females, mean age 47 years) consuming at least 14 (women) or 21 (men) standard units of alcohol (SUAs) per week and scoring ≥ 8 (men) or 6 (women) on the Alcohol Use Disorders Identification Test.

Measurements: On-line questionnaires administered to assess SUAs and assess quality of life (AQoL-8D) and resource use. Outcome measure was responder (≤ 14/≤ 21 SUAs) for the CEA and quality-adjusted life years (QALYs) for the CUA. Net benefit regression was used to estimate cost-effectiveness for each study arm. Bootstrapping and sensitivity analyses were performed to account for uncertainty.

Interventions: Five weekly modules including personalized normative feedback, motivational interviewing, goal setting, problem-solving and emotion regulation, provided with adherence-focused guidance [n = 142; responders: n = 73 (51.4%); QALYs = 0.364, standard error (SE) = 0.006] or without guidance [n = 146; n = 66 (45.2%); 0.359, 0.007]. Controls were on a waiting-list [n = 144; n = 38 (26.4%); 0.342, 0.007].

Findings: From a societal perspective, the guided intervention had a probability of 55% (54%) of being the most efficient strategy at a willingness-to-pay (WTP) of €0 per responder (QALY) gained, compared with the unguided intervention and the control condition. At a WTP of €20 000 per QALY gained, the probability was 78%. From an employer's perspective, the guided intervention had a higher probability of a positive return on investment (81%) compared with the unguided intervention (58%).

Conclusion: A guided internet-based intervention to reduce problematic alcohol consumption in employees appears to be both cost-beneficial and cost-effective.

KEYWORDS

Cost-effectiveness, cost–utility, economic evaluation, employees, internet-based intervention, problematic alcohol consumption, QALY

INTRODUCTION

Alcohol has a major impact on public health. Alcohol misuse leads to a large burden of disease, including cardiovascular diseases, mental health conditions, digestive diseases, cancer and injuries [1]. Worldwide, approximately 3.8% of all deaths and 4.6% of disability-adjusted life-years (DALYs) are attributable to alcohol [2]. By 2030, alcohol use disorders (AUDs) are estimated to be the fourth leading cause of disability in high-income countries [3].

Consequently, alcohol use is associated with substantial economic costs for society (e.g. health-care, law enforcement, social and indirect costs stemming from productivity losses). In middle- and high-income countries these costs account for approximately 1% of the gross domestic product (GDP) [2]. Approximately half the socio-economic costs (e.g. 0.64% of the GDP per country annually) are attributable to sick leave, reduced job performance, early retirement, involuntary unemployment and premature mortality [4].

Hence, programmes directed at employees to reduce problematic drinking can potentially benefit the employee, the employer and society as a whole. Problematic drinking refers to alcohol consumption that is likely to lead to physical or psychosocial harm and is defined as an average rate of consumption of more than 14 weekly standard units of alcohol (SUAs, 10 g of ethanol) for women and more than 21 weekly SUAs for men [5]. Evidence suggests that screening and brief interventions are effective at reducing excessive alcohol consumption [6]. However, it seems unlikely that brief interventions alone curb the prevalence of problem drinking [7].

Low-threshold internet- and mobile-based interventions (IMIs) seem to be a promising option, by which evidence-based interventions designed to reduce alcohol-related problems could be delivered less intrusively [8,9]. In addition, IMIs have the potential of attracting individuals who would otherwise not make use of traditional services due to practical concerns or time constraints [10]. In particular, IMIs can be anonymously accessed whenever required: two factors that are especially relevant for problematic drinking [11].

Based on an individual participant data meta-analysis [12], IMIs for adult problem drinking have been shown to be effective in reducing the weekly consumption of SUAs [−5.02 SUAs, 95% confidence interval (CI) = − 7.57 to −2.48, P < 0.001]. Guided IMIs seemed to yield better outcomes than unguided IMIs (−6.78 SUAs, 95% CI = − 12.11 to −1.45, P = 0.013) [12].

With respect to the economic merit of IMIs for problematic drinking, a modelling study revealed that the implementation of IMIs could substantially increase the cost-effectiveness of health-care systems for AUDs [13]. A recent systematic review on the cost-effectiveness

of IMIs for substance use disorders suggested that IMIs for AUDs provide good value for money, from both a public health-care and a societal perspective [14]. The only study comparing an unguided and a guided IMI for problematic drinking in adults in a substance abuse treatment centre suggested that a guided IMI offered better value for money than an unguided IMI [15].

However, to the best of our knowledge, no study has yet evaluated the economic merit of (un-)guided IMIs for problematic drinking specifically in employees, from neither the societal nor the employer's perspective. Elsewhere we have reported the primary outcome with regard to the reduction of self-reported quantity of alcohol consumption in standard units of alcohol [16]. Here, we evaluated the cost-effectiveness and cost–utility of an unguided and guided IMI for problematic alcohol use in employees relative to a waiting-list control condition from a societal perspective and the cost–benefit from the employer's perspective, within a time horizon of 6 months.

METHODS

Study design

The execution and reporting of the health economic evaluation followed the declaration of the Consolidated Health Economic Evaluation Reporting Standards [17] and the guidelines of the International Society for Pharmacoeconomics and Results Research [18]. The economic evaluation was conducted alongside a three-arm pragmatic randomized controlled trial evaluating the effects of both an internet-based intervention with adherence-focused guidance and without guidance (i.e. self-help) to reduce alcohol consumption in employees compared to a waiting-list control group with unrestricted access to treatment-as-usual (TAU). Detailed information regarding the study design can be found elsewhere [16,19]. The study was approved by the University of Lüneburg (Germany) ethics committee (no. Boss201404_OT) and registered in the German clinical trial register for clinical studies (DRKS00006105).

Participants

Participants were recruited in Germany during the period from October 2014 to February 2016. An open recruitment procedure was used (e.g. print newspaper articles, open-access websites), which was supported by some German health insurance companies

(e.g. BARMER, KKH, BKK) via announcements in their membership magazines and on their websites). The recruitment strategy employed in this study is the same that will be employed when the intervention is delivered under real-world conditions, thus strengthening the ecological validity of the study.

Individuals (aged 18 years and above) were included into the study if they were (a) currently (self-)employed, (b) reported drinking at least 14 (women)/21 (men) standardized units of alcohol (SUAs) per week with (c) having a score of ≥ 8/6 for men/women on the Alcohol Use Disorders Identification Test (AUDIT) [20]. Exclusion criteria included (a) any past psychosis or drug dependence (self-disclosed); (b) notable suicidal risk, as indicated by a score greater than 1 on item 9 of the Beck Depression Inventory [21]; or (c) current treatment for alcohol-related problems or work-related stress. The Consolidated Standards of Reporting Trials (CONSORT) study flow-chart and participants' characteristics at baseline can be found elsewhere [16]. In brief, 434 employees were recruited into the trial. Two participants withdrew from the study and requested their data to be deleted. Thus, the final ITT sample consisted of 432 participants, with 146 randomized to the unguided intervention, 142 to the guided intervention and 144 to the waiting-list control condition. At post-treatment, 339 participants (78.5%) were still participating, whereas at 6-month follow-up, 270 participants (62.5%) completed the follow-up questionnaires. The three groups differed with regard to missing data on primary and secondary outcomes at T2 ($P = 0.032$), but not at T3 ($P = 0.092$) [16]. The average participant was female ($n = 256$, 59.5%; males: $n = 178$, 40.5%), 47 years of age [standard deviation (SD) = 19], full-time employed (69.7%), with an average working experience of 23 years (SD = 11) and drinking 29.6 SUAs weekly (SD = 15.8) [16].

Randomization and masking

Study participants were randomly assigned at individual level in a 1:1:1 ratio with a block size of three to the study groups by an independent researcher, who was not otherwise involved in the study, using an automated, computer-based, random integer generator (randomisation.eu). Detailed information about the randomization procedure can be found elsewhere [16]. During the randomization procedure, group allocation was concealed from participants, researchers involved in recruitment and eCoaches. After randomization, study participants were aware of their group allocation as they received immediate or delayed access to the internet-based intervention.

Interventions

All study participants had unrestricted access to TAU. The German S3-Guideline for Alcohol-related Disorders recommends brief interventions in outpatient settings for problematic drinking [e.g. general practitioners (GPs), psychotherapists] [22]. In our pragmatic study, we did not interfere in TAU. Instead, we maintained a naturalistic TAU

condition to represent current routine care as best as possible. It should also be noted that health-care use was measured in detail (see Measures).

Web-based intervention

The web-based alcohol intervention (GET.ON Clever weniger trinken; CWT – be smart – drink less) consisted of five weekly modules which were based on evidence-based treatments of alcohol use disorders [23,24], e.g. motivational interviewing, methods to control drinking behaviour and relapse prevention. In addition, the intervention contained elements of emotion regulation [25]. A detailed description of the intervention can be found elsewhere [19]. Participants in the guided condition were supported by an eCoach (e.g. a trained psychologist). Guidance in this study was primarily based on the supportive-accountability model of guidance in internet interventions [26] and consisted of two elements: adherence monitoring and feedback on demand, which was provided within 48 hours. Participants in the guided intervention group completed three modules on average, while participants in the unguided intervention group completed 2.5 modules [16].

Outcome measurements

Health-related outcomes

Drinking outcomes were operationalized as the number of participants who complied with the low-risk guideline for problematic drinking at 6-month follow-up. Responders were defined as having consumed no more than 14 (for women) or 21 (for men) SUAs weekly.

Health-related quality of life was measured using the Assessment of Quality of Life (AQoL-8D) at baseline, post-treatment and 6-month follow-up. The AQoL-8D is a reliable and validated quality of life instrument [27]. It measures health-related quality of life across eight dimensions (independent living, relationships, mental health, coping, pain, senses, self-worth and happiness) and generates patient preference-based utilities on a scale of 0 (death) to 1 (perfect health), using the time trade-off method [28]. Quality-adjusted life-years (QALYs) gained were estimated by calculating the area under the curve (AUC) of linearly interpolated AQoL-8D utilities between measurement points to cover the whole 6-month follow-up period.

Resource use and costing

Costs were measured from both societal and the employer's perspectives. When the societal perspective was applied, all costs (i.e. intervention, health care, patient and family and productivity costs) related to the intervention were taken into account irrespective of who pays or benefits from them. When applying the employer's perspective, only costs and economic benefits pertinent to employers

were included (i.e. costs or cost reductions stemming from changes in absenteeism and presenteeism) plus intervention costs assuming that the latter would be paid for by the employer. We used the Trimbos and iMTA questionnaire for costs associated with psychiatric illness (TiC-P) [29], a retrospective questionnaire with a 3-month recall period, for collecting data on health-care use, patient and family costs and productivity costs. Accumulated costs were estimated using the AUC method to linearly interpolate 3-month costs as measured at each measurement point to cover the full follow-up period of 6 months. The TiC-P was adapted for use in Germany and has been used in a series of cost-effectiveness studies [30–32]. Costs were expressed in Euros and indexed from 2011 to 2015, the year the study was conducted, with an index factor of 1.05 based on the German consumer price index [33]. Costs were converted to pounds sterling (£) using the purchasing power parities reported by the Organization for Economic Cooperation and Development [34]. For the reference year 2015, €1 was equated to £0.89.

Intervention costs

At the time of conducting the study, the market price of the unguided internet-based intervention provided by the GET.ON Institute, a commercial health-care service provider, was €79 (£70) per participant, whereas it was €189 (£168) for the guided intervention including the time that eCoaches spent on coaching and administrative tasks, costs for website maintenance and hosting, technical support and overheads.

Health-care costs

We used two German guidelines for calculating health-care costs [35,36]. Health-care costs on a per-participant level were based on available lists of unit cost prices [36]. Unit cost prices were as follows: €21.06 (£18.74) for a visit to the GP, €46.96 (£41.79) for a session with a psychiatrist, €81.98 (£72.96) for a session with a psychotherapist and €17.14 (£15.26) for allied health services. Hospital stays were computed at €356.70 (£317.46) for an inpatient day in a psychiatric hospital (Supporting information, Table S2). Costs were estimated by multiplying the units of resource use with corresponding unit cost prices. The costs of prescribed medication were based on the German drug registry, Rote Liste [37].

Patient and family costs

Out-of-pocket payments were directly obtained from participants. Costs for travelling were valued at €0.30 (£0.27) per kilometre. Productivity losses from unpaid work (e.g. household chores, shopping, child care) were valued using the replacement cost method [38,39] with an estimated value of €19.25 (£17.13) per hour (i.e. the average gross wage of domestic help per hour).

Productivity costs

We followed the human capital approach to value costs due to absenteeism [40]. Lost working days due to absenteeism were valued at the gross average income of participants per day. Lost working days due to presenteeism were computed by taking into account the number of working days for which the participant reported reduced functioning weighted by an inefficiency score for those days (Osterhaus method) [41].

Statistical analysis

The study was not powered to statistically test differences in health economic outcomes. Therefore, we took a probabilistic decision-making approach to make health economic inferences (e.g. cost-effectiveness acceptability curves) [42] and did not test for statistically significant differences in costs between study groups. Due to the 6-month time horizon, we did not discount costs and effects.

Handling missing data

All findings were reported in accordance with the CONSORT [43], following the intention-to-treat principle. Little's overall test of randomness indicated that missingness in cost and outcome data occurred completely at random ($P = 0.57$). We employed a Markov chain Monte Carlo multivariate imputation algorithm as implemented in SPSS version 26, with 100 estimations per missing value. We did not impute costs due to inpatient care, because only six participants (1.6%) were hospitalized during the 6-month follow-up period leading to unstable imputations. Data were first aggregated over the 100-fold imputations and these aggregated data were used in the bootstrapped analyses.

Analyses of health-related outcomes and costs

We tested for group differences in the number of responders using Pearson's χ^2 analysis [16]. Total adjusted QALYs were estimated using ordinary least-squares regression analyses with robust standard errors controlling for AQoL-8D baseline scores [44]. Cost categories as well as costs from the employer's and societal perspectives per study group were assessed by bootstrapping ($n = 2500$) ordinary least-squares regression models. In addition, we estimated total societal costs with a generalized linear regression model. We used the modified Park's test [45] to determine the family distribution (i.e. gamma distribution). The model was adjusted for baseline costs [46], initial depressive symptom severity and alcohol consumption as associated factors of resource utilization. We used a link identity function providing additive effects of covariates [47].

Cost-effectiveness and cost–utility analyses from the societal perspective

Net monetary benefit (NMB) regression framework was used to obtain cost-effectiveness and cost–utility estimates for each condition from the societal perspective. All three conditions were included simultaneously in the NMB analyses, with no need to specify the comparator [48]. The NMB was calculated as $\lambda \times Ek - Ck$, where Ek is the arithmetic mean of health-related outcomes (e.g. responders, QALYs), Ck is the mean of costs for the kth comparator and λ is the willingness-to-pay (WTP) threshold. NMB values were calculated at each WTP (QALYs: €0–50 000 at €5000 intervals; responder: €0–5000 at €500 intervals). At each threshold, 2500 bootstrap model iterations of the linear regression models of the NMB adjusted for baseline cost, utility values (only when QALYs were used), initial depressive symptom severity and alcohol consumption as associated factors for health-related outcomes and resource utilization were performed. For an n-way comparison, the alternative with the highest net benefit has the highest probability of being cost-effective [49]. Cost-effectiveness acceptability curves (CEACs) were generated to assess for each condition the probability of being the most cost-effective alternative compared to the other two conditions over a range of willingness-to-pay thresholds [50]. CEACs were based on the bootstrapped regression models. In each of the bootstrap iterations, the probability that each intervention was the most cost-effective alternative was reported as the proportion of replicates, in which each intervention had the highest NMB.

Cost–benefit analyses from the employer's perspective

Two metrics were applied: (1) net benefits (NB = benefits – costs; amount of money gained after costs are taken into account) and (2) return-on-investment (ROI) [ROI = (benefits – costs)/costs × 100%; percentage of profit per Euros invested], where costs are defined as intervention costs and benefits as the difference in productivity costs between the intervention groups and the control condition. Both metrics were each estimated by bootstrapping a linear regression model adjusted for baseline costs due to absenteeism and presenteeism, and initial depressive symptom severity (n = 2500). The probability of financial return was estimated by the proportion of positive estimates (e.g. NB > 0, ROI > 0%).

Sensitivity analyses

To assess the robustness of the base case findings, six sensitivity analyses were performed. First, we repeated the main analyses but without covariate adjustments. Secondly, we applied a more conservative low-risk guideline for problematic drinking by defining responders as having consumed no more than seven (for women) or 14 (for men) SUAs weekly [51,52]. Thirdly, we performed analyses assuming reduced effects in both intervention groups (i.e. approximately the

95% CI of weekly alcohol consumption and QALYs). Fourthly, we applied winsorizing, where cost outliers (e.g. those above the 95th percentile) are not removed, but their extreme values are replaced by the value at the 95th percentile [53]. Fifthly, we assessed the impact of inpatient care on the results of the main analyses by excluding costs due to inpatient care from the analyses. Finally, we varied the costs of the intervention by plus 50% to reflect uncertainties about the actual market price, both in net monetary benefit regression analyses from the societal perspective and cost–benefit analyses from the employer's perspective.

RESULTS

Health-related outcomes

At 6-month follow-up, both intervention groups yielded statistically significant higher rates of response to the low-risk drinking threshold (unguided: n = 66, 45.2%; guided: n = 73, 51.4%) compared to the control group (n = 38, 26.4%; unguided: $\chi^2_{(1)}$ = 11.16, P = 0.001; guided: $\chi^2_{(1)}$ = 18.85, P < 0.001). Total adjusted mean QALYs were higher in the guided intervention group (0.364 QALYs: 95% CI = 0.359–0.369; SE = 0.006) compared to the unguided intervention group (0.359 QALYs: 95% CI = 0.354–0.364; SE = 0.007) and the control condition (0.342 QALYs: 95% CI = 0.337–0.357; SE = 0.007). Adjusted incremental differences in QALYs between the interventions groups and the control condition were statistically significant [unguided: Δ(e) = 0.018 QALYs, 95% CI = 0.010–0.025; guided: Δ(e) = 0.022 QALYs, 95% CI = 0.014–0.029].

Costs

Baseline costs were similar for the unguided intervention group [€992 (£883), SD = 1477] and the control condition [€917 (£816), SD = 1580] but higher in the guided intervention group [€1297 (£1154), SD = 2513]. Table 1 presents the bootstrapped (n = 2500) imputed mean cumulative per-participant costs (in €) by condition during the 6-month follow-up period. Direct medical and patient and family costs were comparable for all three groups. In both intervention groups, costs due to presenteeism were lower compared to costs caused by absenteeism. The opposite applied to the control condition. With regard to costs stemming from absenteeism, both intervention groups showed similar (unguided: €661, 95% CI = €462– 860; guided: €670, 95% CI = €467–872), but higher cost levels compared to the control condition (€561, 95% CI = €360–761). The guided intervention group generated the fewest costs due to presenteeism (€510, 95% CI = €352–667) compared to the unguided intervention group (€648, 95% CI = €492–803) and the control condition (€628, 95% CI = €472–785). The control condition and the unguided intervention group showed comparable cost levels [€1782 (£1586), 95% CI = €1435–2130 versus €1774 (£1579), 95% CI = 1429–2119]; however, both groups were less costly than the guided intervention group

TABLE 1 Bootstrapped (*n* = 2500) imputed mean cumulative per-participant costs (in €) by condition over a 6-month follow-up period

	Waiting-list control condition (n = 144)		Unguided intervention group (n = 146)		Guided intervention group (n = 142)	
	Mean, €	(95% CI)	Mean, €	(95% CI)	Mean, €	(95% CI)
Intervention costs	–		79	–	189	–
Direct medical costs[a]						
GP	40	34–47	42	35–48	43	36–49
Mental health care	64	37–92	46	18–73	70	43–98
Antidepressants	15	6–23	19	10–27	21	12–29
Allied health services[b]	36	19–53	30	13–46	48	31–65
In-patient care	183	56–310	27	0–153	126	0–253
Patient and family costs[a]						
Over-the-counter drugs	24	18–30	22	16–28	23	17–29
Out-of-pocket expenses[c]	42	24–59	19	1–36	34	17–52
Travel	8	5–10	7	5–10	4	2–6
Unpaid work	183	116–250	175	109–242	217	150–285
Productivity costs[a]						
Absenteeism	561	360–761	661	462–860	670	467–872
Presenteeism	628	472–785	648	492–803	510	352–667
Employer's perspective						
Intervention costs + productivity costs	1189	897–1481	1388	1098–1678	1368	1074–1662
Societal perspective						
Total societal costs[d]	1782	1435–2130	1774	1429–2119	1954	1604–2303

[a]Costs of cost categories were estimated based on bootstrapped (*n* = 2500) linear regression models.
[b]For example, physiotherapist, massage, occupational therapist.
[c]For example, allied health services without prescription.
[d]Includes all cost categories. Total societal costs were estimated based on a bootstrapped (*n* = 2500) linear regression model. Due to rounding, columns do not add up correctly. CI = confidence interval.

[€1954 (£1739), 95% CI = 1604–2303]. However, adjusted total costs were nearly identical for both intervention groups and lower compared to the control condition (Table 2).

Cost-effectiveness and cost–utility analyses from the societal perspective

The control condition yielded the smallest effects in terms of treatment response and QALYs gained and did so at higher costs compared to both intervention groups, reflected in the lowest mean NMBs (Table 2). The CEACs (Fig. 1) showed that the guided intervention tends to be the preferred alternative compared to the unguided intervention and the control condition, with a probability of 55 and 54% of being the most cost-effective strategy at a WTP of €0 per responder and QALY gained, respectively. The probability increases to 78% when increasing the WTP to €20 000 (£17 800) per QALY gained and 86% at a WTP of €5000 (£4450) per additional responder. Despite the 31 and 32% probability of the unguided intervention being the most cost-effective strategy at a WTP of €0 per responder and QALY gained, respectively, its probability diminishes with increasing WTPs (e.g. 22% at a WTP of €20 000 per QALY gained). The control

condition has the lowest chance of being the most cost-effective strategy, with a probability of 14% for both health outcomes at a WTP of €0 that decrease to 0% as WTPs increase.

Cost–benefit analyses from the employer's perspective

The unguided intervention condition showed a net benefit per participant of €29 (£26) (95% CI = 23–34), which was €109 (£97) (95% CI= €105–114) in the guided intervention condition. The ROI was 36% (95% CI = 30–43%) and 58% (95% CI = 55–60%), respectively. The probability of a positive return on investment was 58% for the unguided and 81% for the guided intervention condition (Table 3).

Sensitivity analyses

Results of the sensitivity analyses are summarized in Supporting information, Table S1. Analyses based on linear regression models without covariate adjustments supported the conclusion that the guided intervention has the highest probability of being cost-effective at a WTP

TABLE 2 Results from the societal perspective of adjusted cost–effectiveness and cost–utility analyses based on 2500 bootstrapped net monetary benefit regression models

Study group	Adjusted mean total societal costs (€)[a]	95% CI	Treatment responder (n)	(%)	Adjusted mean QALYs[b]	95% CI	Adjusted mean NMB at WTP of €5000/treatment responder[c]	95% CI	Adjusted mean NMB at WTP of €20 000/QALY gained[d]	95% CI
Control	1942	1671–2213	38	26.4	0.342	0.337–0.357	464	−76 – 1004	4939	4661–5218
Unguided	1840	1583–2096	66	45.2	0.359	0.354–0.364	1498	943–2052	5367	5090–5643
Guided	1865	1592–2137	73	51.4	0.364	0.359–0.369	1852	1290–2413	5498	5217–5778

aMean societal costs were estimated by a generalized linear regression model with gamma family distribution and link identity function adjusted for baseline costs, initial depressive symptom severity and alcohol consumption.

bQuality–adjusted life-years (QALYs) were estimated by an ordinary least-squares regression model adjusted for baseline utility values.

cNet monetary benefit (NMB) linear regression models were adjusted for baseline cost, initial depressive symptom severity and alcohol consumption.

dNet monetary benefit (NMB) linear regression models were adjusted for baseline cost, utility values, initial depressive symptom severity and alcohol consumption. CI = confidence interval; WTP = willingness to pay.

of €20 000 per QALY gained, however; the probability was lower (55%) compared to the adjusted analysis (78%) (Supporting information, Fig. S1). The application of stricter limits for problematic drinking led to converging probabilities for the guided (56%) and unguided intervention (44%) to be the most cost-effective preventive intervention at a WTP of €5000 (Supporting information, Fig. S2), assuming that reduced effects on health-related outcomes in both intervention groups did not influence the economic outcomes (Supporting information, Fig. S3). Winsorizing extreme values to the level at the 95th percentile did not affect cost-effectiveness outcomes (Supporting information, Fig. S4). Hospital costs were higher in the guided intervention group compared to the unguided group and the control condition, so excluding these costs increased the guided intervention's probability to be the most efficient option to 72% (85%) at a WTP of €0 (€20 000) per QALY gained (Supporting information, Fig. S5). Increasing intervention costs by 50% led to an almost equal likelihood that the unguided (46%) and guided interventions (41%) constitute the most efficient option from the societal perspective at a WTP of €0 per QALY gained. At a WTP of €20 000 per QALY gained, the probability of being cost-effective was higher for the guided intervention (64%) compared to the unguided intervention (36%) (Supporting information, Fig. S6). ROI was negative for the unguided intervention when intervention costs were increased by 50%, while the probability of a positive financial return was just greater than 50% for the guided intervention group (Table 3).

DISCUSSION

Main findings

Our study was designed to evaluate the cost-effectiveness and cost–utility of the unguided and guided intervention as adjunct to TAU to reduce problematic alcohol use in employees, in comparison with a waiting-list control condition (WLC) with unrestricted access to TAU from a societal and an employer's perspective. Statistically significant differences favouring both intervention groups compared to the WLC were found for both health outcomes (e.g. treatment response and QALYs). From a societal perspective, the guided intervention had the highest probability of being cost-effective (e.g. 78% at a WTP of €20 000 per QALY gained). From an employer's perspective, the guided intervention showed higher net benefits than the unguided intervention and the WLC. Probability of financial return ranged from 58% (unguided IMI) to 81% (guided IMI).

Comparison to previous research

A systematic review provided evidence that screening and brief interventions in primary care are cost-effective in relation to various comparators to tackle alcohol-related harms [54]. Although the effectiveness of IMIs for adult problem drinking is well established [12], there is a critical gap in health economic evidence for such
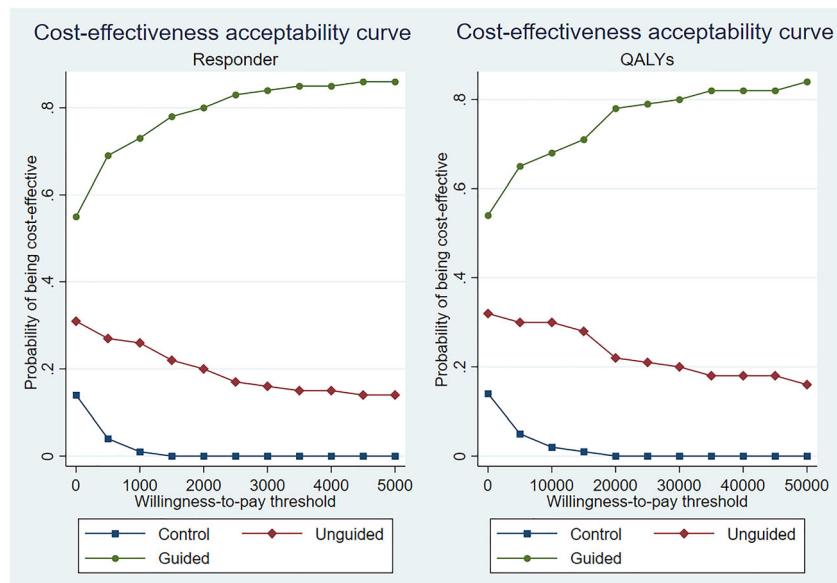
FIGURE 1 Cost-effectiveness acceptability curves from the societal perspective

TABLE 3 Results from the employer's perspective of adjusted cost–benefit analyses based on 2500 bootstrapped linear regression models (main and sensitivity analyses)

	Costs[a]		Benefits[b]		Financial return				
	Total	95% CI	Total	95% CI	NB[c]	95% CI	ROI[d] (%)	95% CI	P[e] (%)
Main analyses									
Unguided intervention	79	NA	108	102–113	29	23 to 34	36	30 to 43	58
Guided intervention	189	NA	298	294–303	109	105 to 114	58	55 to 60	81
Sensitivity analysis[f]									
Unguided intervention	118.5	NA	108	104–114	−10	−15 to −5	−8	−13 to −4	47
Guided intervention	283.5	NA	298	292–301	14	9 to 18	5	3 to 7	54

[a]Net benefit (NB) linear regression models were adjusted for baseline costs due to absenteeism and presenteeism and initial depressive symptom severity.
[b]Return on investment (ROI) linear regression models were adjusted for baseline costs due to absenteeism and presenteeism, and initial depressive symptom severity.
[c]Probability of positive return on investment.
[d]Intervention costs increased by 50%.
[e]Costs are intervention costs.
[f]Benefits are the difference in productivity costs between the intervention groups and the control condition. NA = not available; CI = confidence interval.

interventions. To our knowledge, this is the first trial-based economic evaluation of an unguided and guided intervention to reduce problematic drinking in employees using a societal and an employer's perspectives. As such, results from our trial add to the growing evidence pointing to the cost-effectiveness of IMIs for mental health disorders [14,55–57]. Blankers *et al.* (2012) compared an unguided and a guided IMI for harmful alcohol use in adults in a substance abuse treatment centre from a societal perspective. Results of the current health economic evaluation are in agreement with these findings. In parallel to our findings, the guided IMI provided better value for money than unguided self-help. Compared to our results, cost–utility analyses revealed a slightly lower probability (60%) of the guided intervention being cost-effective compared to the unguided IMI at a ceiling ratio of €20 000 per QALY gained [15]. In addition, our findings agree with available health economic evidence from a recent systematic review

showing the health economic benefits of IMIs for alcohol use disorder. Probabilities that IMIs were cost-effective from a societal and a public health care perspective, respectively, ranged from 60 to 84% [14].

Our results from the employer's perspective are also in line with findings from a recent systematic review showing that targeting substance misuse in employees improves both employees' wellbeing and productivity [58]. Regarding the ROI analyses, our findings compare favourably to a systematic review on the costs and benefits of health promotion interventions at the work-place (n = 12 RCTs), which revealed on average a negative ROI (ROI = −0.22, 95% CI = 0.27–0.16; min = −4.3; max = 5) [59]. In addition, the percentages of profit per Euros invested of 37% (95% CI = 30–44%) and 61% (95% CI = 58–63%) for the unguided and guided intervention, respectively, are comparable to a study on a guided internet-based intervention targeting work-related stress in employees (ROI = 61%) [60].

Limitations

This study has some limitations. First, the time horizon of this study was limited to 6 months. It is possible that health effects were maintained after 6 months, but they also might diminish over time. The same holds true for decreased costs and productivity gains. As additional costs such as premature death or accidents were not taken into account, costs only reflect short-term costs. Further studies should thus assess the long-term clinical and cost-effectiveness of IMIs for problematic alcohol use to shed light on its longer-term cost-effectiveness. In addition, the societal perspective was incomplete by omitting crime and criminal justice, future medical and opportunity costs (e.g. time spent on using the intervention, travelling time). However, as this is a preventive intervention, crime and criminal justice costs might not significantly affect the results in this study. Secondly, although the sample size in this trial was sufficient to demonstrate clinical effectiveness, it needs emphasizing that much larger sample sizes are required for hypothesis testing in economic studies due to the large variance of costs relative to normally distributed health effects [61]. Therefore, future studies employing larger sample sizes are recommended to allow for robust evaluations of cost changes and sustainability of interventions such as IMIs. Thirdly, the IMIs were compared to a waiting-list control condition in the present trial. However, pharmaco-economic guidelines recommend standard care (e.g. brief face-to-face alcohol interventions) as comparator [62]. Future studies should thus directly compare the cost-effectiveness of IMIs versus face-to-face interventions. Fourthly, the trial participants were highly educated. Evidence suggests that better treatment adherence is predicted by higher education [63]. Attrition has been suggested to be an issue, especially in internet-delivered interventions [64]. Hence, we cannot predict the uptake of such an intervention in less educated people or among people with a lower socio-economic status. It is thus warranted to conduct economic evaluations in these specific population segments. Fifthly, we did not conduct diagnostic interviews to identify participants with alcohol use disorder. However, including participants with a wide range of consumed alcohol units reflect the real-life situation in the general population in high-income countries [65]. Finally, the research context may have led to self-selection of individuals who might be more motivated and committed to engage in IMIs than is assumed outside a research context [66]. As a result, findings might not be generalizable to the wider target population, but are likely to be representative for precisely those people willing to use IMIs in the first place.

Implications

The current study shows that an internet-based intervention may not only be effective in reducing weekly alcohol consumption, but also that achieving and maintaining a marked reduction in drinking is associated with significant increases in health-related quality of life. As the population segment targeted in the current study had a lower than average health-related quality of life when entering the study [67], this finding underscores the importance of offering this target group an eHealth intervention to curb their problematic alcohol use.

Internet-based interventions for mental disorders have often been touted as potential cost-saving alternatives to face-to-face individual or group therapy [55,56]. Findings from our study add to the evidence base that IMIs have indeed a high probability of being cost-effective in reducing problematic alcohol consumption among employees. The IMIs that we evaluated are cost-effective and even dominant, in the sense that for fewer costs better health gains were achieved. Furthermore, the outcomes of our ROI analyses could encourage employers and decision-makers in public health to offer IMIs to employees because there are favourable ROIs, as the IMIs led to increases in productivity (less absenteeism and less presenteeism), in particular via an IMI with adherence-focused guidance. All in all, the findings highlight the importance of promoting awareness and access to this type of intervention for problematic drinking.

Considering that only relatively few health-care professionals actually administer face-to-face brief alcohol interventions, and that only a small proportion of patients who might benefit accept those treatment offers [7], it would be worthwhile to integrate IMIs for problematic drinking into routine practice. However, some risks need to be considered when scaling-up IMIs. There are no guarantees that adherence and (by proxy) effectiveness found in a research context will be maintained if such an intervention is scaled-up in the general population, at the work-place or in primary care. In addition, the high-quality information and communication technology resources (e.g. stable and secure internet connections) may not be available to the same extent outside the research setting.

CONCLUSION

Findings suggest that internet-based interventions to reduce problematic alcohol consumption in employees are both cost-beneficial (i.e. the financial benefits exceed the intervention costs and thus the return on investment is positive) and cost-effective (i.e. the health effects gained present good value for the money invested). However, more studies with longer follow-up periods and standard care as comparator are needed to further substantiate these findings. Given the evidence for the effectiveness, feasibility and acceptance of internet-based interventions to reduce problematic alcohol consumption, their potential cost-effectiveness and scalability might strategically pave the way to alleviate the health and economic burden related to problematic alcohol use in an affordable manner.

DECLARATION OF INTERESTS

AUTHOR CONTRIBUTIONS

Claudia Buntrock: Conceptualization-Lead, Formal analysis-Lead, Methodology-Lead, Writing-original draft-Lead. **Johanna Freund:** Writing-original draft-Supporting, Writing-review & editing-Supporting. **Filip Smit:** Conceptualization-Supporting, Formal analysis-Supporting, Methodology-Supporting, Supervision-Supporting, Writing-review & editing-Supporting. **Heleen Riper:** Conceptualization-Supporting, Supervision-Supporting, Writing-review & editing-Supporting. **Dirk Lehr:** Conceptualization-Supporting, Funding acquisition-Equal, Project administration-Supporting, Supervision-Supporting, Writing-review & editing-Supporting. **Leif Boß:** Conceptualization-Supporting, Data curation-Lead, Investigation-Lead, Project administration-Lead, Writing-review & editing-Supporting. **Matthias Berking:** Conceptualization-Supporting, Funding acquisition-Equal, Writing-review & editing-Supporting. **David Daniel Ebert:** Conceptualization-Supporting, Funding acquisition-Equal, Supervision-Supporting, Writing-review & editing-Supporting.

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