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Evaluating Community-based Rehabilitation: can propensity score matching be applied to cross-sectional data?

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-022544
Article Type:	Research
Date Submitted by the Author:	22-Feb-2018
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Keywords:	epidemiological methods, disability, social inequalities

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3 Evaluating Community-based Rehabilitation: can propensity score matching be applied to
4 cross-sectional data?
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29 Keywords: disability, epidemiological methods, social inequalities
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31 Word count: 3019
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ABSTRACT

Objectives: Community-Based Rehabilitation (CBR) is a multi-sectoral approach working to equalize opportunities and include people with disability in all aspects of life. The complexity of CBR and often limited resources lead to challenges when attempting to quantify its effectiveness, with randomization and longitudinal data rarely possible. Statistical methods, such as propensity score matching (PSM), offer an alternative approach to evaluate a treatment when randomization is not feasible. The aim of this study is to examine whether PSM can be an effective method to facilitate evaluations of results in CBR when data are cross-sectional.

Design: Cross-sectional survey

Setting and Participants: Data were collected using the World Health Organization's CBR Indicators in Vietnam, with treatment assignment (participating in CBR or not) determined by province of residence. 298 participants were selected through government records.

Results: PSM was conducted using one-to-one nearest neighbour method on ten covariates. Before matching, significant differences between groups were found for six of the ten covariates. PSM successfully adjusted for bias in all covariates in the matched sample (74 matched pairs). An independent t-test compared the outcome of "community inclusion" (a score based on selected indicators) between CBR and non-CBR participants both before and after matching, with CBR participants having significantly worse community inclusion scores than non-CBR participants. This result did not differ before and after matching.

Conclusion: PSM successfully reduced bias between groups, though this did not affect the tested outcome. PSM should be considered when analyzing cross-sectional CBR data, especially for international comparisons where differences between populations may be greater.

Strengths and limitations of this study

- The complexity of CBR and often limited resources available in the field lead to challenges in research attempting to quantify its effectiveness and to a heavy reliance on non-randomized cross-sectional data, implying the need for statistical approaches, such as PSM, to account for these limitations.
- PSM attempts to mimic randomization by creating a sample of participants who received the treatment (CBR participants) that is comparable on all observed covariates to participants who did not receive the treatment (non-CBR participants).
- The potential of using PSM for analyzing cross-sectional CBR data was demonstrated, as biases detected in the distribution of covariates between groups before matching were successfully eliminated.
- One of the main advantages of the CBR Indicators, namely the ability to use comparison individuals without disability from the community is lost; as PSM requires that all participants have a non-zero probability of receiving treatment meaning only people with disabilities can be included.
- PSM only controls for known covariates which means that there is a potential for bias if some covariates that affect the outcome are not included.

INTRODUCTION

Community-Based Rehabilitation (CBR) is a multi-sectoral approach working to equalize opportunities and include people with disability in all aspects of community life. It is broadly defined as “a strategy within general community development for the rehabilitation, equalization of opportunities and social inclusion of all people with disabilities”[1]. The wide scope of CBR is further expanded through the various implementing stakeholders involved in CBR, including people with disabilities themselves, their families and communities, and the relevant governmental and non-governmental service sectors. It is due, at least in part, to this extensive definition that reliable and internationally comparable data to monitor and evaluate CBR are scarce. In an effort to synthesize global perspectives on CBR, the World Health Organization (WHO) developed their “Community-Based Rehabilitation Guidelines” in 2010 which have since become accepted as a conceptual framework for CBR[2]. With these guidelines, WHO emphasized the need for a common global framework for monitoring CBR in line with the Convention on the Rights of Persons with Disability (CRPD). With the launch of the global WHO CBR Indicators in 2015, there is now a standardized approach to do this[3,4].

The complexity of CBR leads to challenges in research attempting to quantify its effectiveness[5-7]. Fully experimental studies with randomization are rarely possible for both ethical and practical reasons, which inherently lead to limitations. The possibility of bias arises as the apparent difference in an outcome between two treatment groups may depend on characteristics that affected whether or not an individual received a given treatment, instead of being an actual effect of the treatment. For this reason there has been a recent emphasis on so-called natural experiments, where a range of primarily statistical approaches are used to evaluate a treatment or intervention when randomization is not feasible[8]. One such approach is propensity score matching (PSM).

PSM was first presented in 1983 by Rosenbaum and Rubin as a method to reduce bias due to confounding variables in observational studies[9]. It attempts to mimic randomization by creating a sample of participants who received the treatment that is comparable on all observed covariates to participants who did not receive the treatment. This effectively creates an experimental dataset where the comparison group is, on average, equivalent to individuals in the exposed group on all observed covariates[10-12]. A systematic review comparing 21 PSM studies to 63 RCTs on therapeutic interventions for acute coronary syndromes found that PSM produced more extreme treatment effect estimates when compared with those from RCTs, although these differences were rarely statistically significant[13]. A similar comparison including 20 propensity-score-based studies matched to RCT results was conducted examining critical care medicine and found that propensity-score-based studies report less beneficial effects of treatment in comparison to RCTs[14]. Despite some shortcomings, PSM provides a method for evaluating complex interventions where randomization is not possible.

PSM has been increasingly used in various research fields, including Public Health, to evaluate complex interventions[15]. CBR is considered a complex intervention, and data collection in the field is further hindered by low resources making quantitative longitudinal data collection infeasible and rarely done[6,7,16,17]. This implies that data analysis in the field of CBR relies heavily on cross-sectional data. PSM has already been successfully applied to cross-sectional data[18,19]. Therefore, the main objective of this paper is to examine whether PSM can be an effective method to facilitate evaluations of results in CBR when data are cross-sectional. Data used in the present study were

collected using the WHO CBR Indicators in Vietnam in 2016 with the assignment of persons to the treatment (CBR participants) and non-treatment group (non-CBR participants) determined by province of residence. PSM will be conducted on the outcome of *community inclusion* of people with disabilities, the ultimate goal of CBR in strong alignment with the CRPD, using a sum score of WHO CBR social indicators and an empowerment indicator.

METHODS

Data Collection

Data collection was conducted using the survey questionnaire accompanying the WHO CBR Indicators[3]. These indicators examine differences in health, education, social life, livelihood and empowerment between people with disabilities and other community members. There are two subsets of indicators: base indicators which are broad and should be used in all data collection activities to ensure comparability, and supplementary indicators which can provide more specific coverage, and can be selected depending on the specific CBR goals and strategies of a program. The indicators and corresponding questions used in this paper are presented in Table 1.

Data collection involved a multi-site cross-sectional survey in 2016 in two Vietnamese provinces: Huế, where CBR is fully implemented and all districts have CBR coverage through government implementation and through non-governmental organizations' (NGO) activities; and Hòa Bình, where CBR is not implemented by either government or NGOs. An Android mobile phone application (app), available from WHO for the CBR Indicators, was used to collect data during interviews (app free to download at:

<http://play.google.com/store/apps/details?id=com.universaltools.whocbrsurvey&hl=en>).

People with disabilities were identified prior to the survey by government records. In both provinces a team of five local health care workers were trained by the lead researcher (CM) over two days on how to conduct interviews using the survey questions and the app. Data collection was supervised by CM. Data were collected anonymously and all respondents were informed of the purpose of the study, and then provided verbal (Huế) or written consent (Hòa Bình). In Huế the decision to provide verbal rather than written consent was justified since requiring written consent would embarrass illiterate participants, leading to a decreased willingness to answer further questions truthfully. In instances when the respondent had cognitive limitations that prevented them from being interviewed, or if the respondent was a minor, a proxy interview with a family member was performed. Ethical approval was obtained through the Ludwig-Maximilians-Universität Munich Ethics Commission.

Variables

Outcome Variable

To measure community inclusion, a sum score was created from the social base and supplementary questions, with the addition of the base question from empowerment. These questions all used the same response scale of 1(*Not at all*) to 5(*Completely*) with the final sum score ranging from 4 to 33, with higher scores indicating higher levels of inclusion (Table 1).

Table 1. WHO CBR Indicators and questions used to measure them. Base indicators are shown in bold. The response option for all questions ranged from 1 (Not at all) to 5 (Completely).

Component	Indicator	Survey Question
Social	% of people with disability that feel valued as individuals by members of their community	Do you feel that other people respect you? For example, do you feel that others value you as a person and listen to what you have to say?
	% of people with disability who make their own decisions about the personal assistance they need	Do you get to make decisions about the personal assistance that you need (who assists you, what type of assistance, when to get assistance)?
	% of people with disability make their own decisions about their personal relationships	Do you get to make your own decisions about your personal relationships, such as friends and family?
	% of people with disability who participate in artistic, cultural or religious activities	Do you get to participate in artistic, cultural or religious activities?
	% of people with disability who participate in mainstream recreational, leisure and sports activities	Do you get to participate in community recreational, leisure and sports activities?
	% of people with disability who know their legal rights	To what extent do you know your legal rights?
Empowerment	% of people with disability who make informed choices and decisions	Do you get to make the big decisions in your life? For example, deciding who to live with, where to live, or how to spend your money?

Matching Variables

Data on *age* and *gender* were collected. Age was collected in categories (0-5, 6-12, 13-17, 18-24, 25-44, 45-64, and 65+) which were dichotomized for the analysis[20]. Though data on disability severity were not available, *general health status* was used as a proxy, using the question “How would you rate your health today?”[21]. A variable for *socio-economic status* (SES) was created using a sum score based on the questions “What is the highest level of education you have achieved or are working to achieve?” and “Do you have enough money to meet your needs?”. The first question is commonly used in SES variable creation, and the second question targets wealth[22,23]. The variable *province of residence* corresponded to CBR coverage (no coverage in Hòa Bình, full CBR coverage in Huế). To account for economic differences between the provinces that might not be captured by SES, the covariate *receiving social protection* (such as for loss of income through old age, sickness or disability) was included. Covariates of *financial awareness* (knowing how to get financial services or social protection if needed), *having access to health services when needed*, and *having access to rehabilitation services when needed* were also included. A proxy for autonomy was captured through the covariates of *being involved in decision making regarding medical treatment* and *participating in a self-help group if desired*.

Missing Data

Missing data were low (2.25%). Multiple imputation (five imputations) using fully conditional specification (MICE package in R Studio Version 0.99.903) was used to replace missing data.

Analysis

Matching on the Propensity Score

The number of treated and untreated participants were similar (difference of $n=4$). Therefore, participants were matched using one-to-one nearest neighbour technique, which matched each treated unit to one control that was closest using calipers of width equal to 0.25 of the standard deviation (SD) of the logit of the estimated propensity score[24]. This implies that for a given treated participant, all the untreated participants are identified whose scores are within this specified

distance and then the best match is formed. If no match falls within this distance the participant is excluded. Participants were matched on ten covariates (see *Matching Variables*).

Balance Diagnostics

Baseline comparisons between the covariates were conducted before and after matching. Balance diagnosis was performed using the standardized difference method, which compares the difference in means of each covariate in units of the pooled standard deviation before and after matching[12]. Successful matching is indicated when the absolute standardized differences of means is less than 0.25[25].

Comparing Groups

For the community inclusion outcome, data matched on the ten covariates were compared using an independent t-test, as it cannot be assumed that the outcomes of matched individuals are correlated[26]. Bootstrapping was performed (1000 samples) in order to produce 95% confidence intervals (CI), which has been shown to account for uncertainty in the matching procedure[20].

A sensitivity analysis was performed using the Rosenbaum Bounds for Hodges-Lehmann Point Estimate to assess how robust the findings were to hidden bias due to unobserved covariates ('rbounds' package in R Studio Version 0.99.903). The maximum Gamma (the odds of differential assignment to treatment due to unobserved factors) was set to 2 with increments of 0.1 to test at which point the between group differences are no longer robust[27].

Data cleaning was performed using SPSS version 23 (copyright IBM Corporation). PSM was performed in R Studio (Version 0.99.903) using the 'MatchIt' package.

RESULTS

Data were available from 298 participants, of which 153(51.3%) were male, with a modal age group of 45-64(28.9%). The sample included 151 non-CBR participants and 147 CBR participants.

Before matching CBR participants had higher health status, were more likely to participate in a self-help group, more financially aware and more likely to be receiving social protection while they had worse access to rehabilitation services. Some age differences were also noted (Table 2). In the unmatched sample the absolute standardized difference across the 10 covariates ranged from 0.008 to 1.008 indicating bias.

When CBR participants were matched with non-CBR participants on the logit of the specified propensity score model, 74 matched pairs were formed. This meant that 49.7% of CBR participants were successfully matched to a control. PSM was successful in reducing bias between the covariates in the matched sample, as the standardized differences ranged from 0 to 0.147 with all values falling below the threshold value of 0.25[25] (Table 2).

Table 2. Baseline characteristics of CBR participants and non-CBR participants in the unmatched and matched samples. Absolute standardized differences of means are shown, with differences exceeding the threshold of 0.25 indicated in bold.

Variable	Unmatched Sample			Matched Sample		
	Mean	Mean	Std. dif. of	Mean	Mean	Std. dif. of

		No CBR (n=151)	With CBR (n=147)	means	No CBR (n=74)	With CBR (n=74)	means
Age	0-5	11 (7.2%)	6 (4.1%)	0.161	3 (4.1%)	5 (6.8%)	0.136
	6-12	19 (12.6%)	11 (7.5%)	0.193	7 (9.5%)	5 (6.8%)	0.102
	13-17	4 (2.6%)	6 (4.1%)	0.072	2 (2.7%)	1 (1.4%)	0.068
	18-24	12 (7.9%)	12 (8.2%)	0.008	7 (9.5%)	7 (9.5%)	0.000
	25-44	49 (32.5%)	32 (21.8%)	0.258	23 (31.1%)	22 (29.7%)	0.033
	45-64	42 (27.8%)	44 (29.9%)	0.046	21 (28.4%)	26 (35.1%)	0.147
	65+	14 (9.3%)	36 (24.5%)	0.353	11 (14.9%)	8 (10.8%)	0.094
Gender (male)		80 (53.0%)	73 (50.0%)	0.066	37 (50.0%)	42 (56.8%)	0.135
SES (range 1-10)		3.74±1.32	3.91±1.30	0.235	3.65±1.45	3.67±1.42	0.020
Health status (range 1-5)		2.89±0.77	3.37±0.70	0.683	3.05±0.75	3.14±0.65	0.115
Receiving social protection		74 (49.0%)	117 (79.6%)	1.008	48 (64.9%)	52 (70.3%)	0.141
Access to health services		132 (87.4%)	126 (85.7%)	0.048	66 (89.2%)	66 (89.2%)	0.000
Access to rehabilitation services		128 (84.8%)	123 (83.7%)	0.263	29 (39.2%)	31 (41.9%)	0.054
Self-help group		63 (41.7%)	75 (51.0%)	0.396	31 (41.9%)	32 (43.2%)	0.027
Financial awareness		73 (48.3%)	122 (83.0%)	0.789	51 (68.9%)	55 (74.3%)	0.134
Involved in treatment decisions		47 (31.1%)	65 (44.2%)	0.137	65 (87.8%)	65 (87.8%)	0.000

Note: continuous variables are presented as means ± standard deviation; dichotomous variables are presented as N(%)

To test whether PSM affected the pre-defined outcome of community inclusion, the difference between groups before and after matching were assessed: similar significant differences were found. In the matched sample, CBR participants had worse community inclusion scores (mean=17.86, SD=6.30, 95%CI 16.33-19.24) than non-CBR participants (mean=20.93, SD=6.16, 95%CI 19.42-22.21); $t(146)=2.996$, $p=0.003$. The sensitivity analysis corroborated the results, showing that CBR participants had a median difference in community inclusion score 3.5 points lower than non-CBR participants (Gamma=0). When the Gamma value was increased to 2, the upper and lower bounds did not include zero indicating robust results[27]. These results did not differ from the results before PSM: community inclusion for participants with CBR (mean=18.61, SD=5.38) and without CBR (mean=20.64, SD=6.49); $t(296)=2.935$, $p=0.004$.

DISCUSSION

To our knowledge, this study presents the first use of PSM as a method for analyzing cross-sectional data in the field of CBR. The study analyzed data collected using the WHO CBR Indicators, and found that community inclusion scores of CBR participants were significantly lower than those of non-CBR participants after PSM. Despite bias being detected in the distribution of covariates between groups before matching, the results before PSM did not significantly differ from those after. We conclude that PSM can be successfully applied to cross-sectional CBR data, though in this case the bias reduction provided by PSM did not affect the tested outcome.

PSM has been applied only to longitudinal CBR data so far, but PSM studies using cross-sectional data are available from other fields. These studies had similar results in terms of the methodological success of PSM, but unlike our study they had final outcomes in line with their hypotheses. One such example is the study from Jalan and Ravallion which examines the effect of an employment-based poverty reduction program on income gain, accounting for pre-intervention and foregone income[19]. Through the trial of three PSM methods, they were able to reduce the differences

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3 between the two populations and to demonstrate the effectiveness of the program. Another such
4 example is the study from Becerril and Abdulai showing the positive impact of new maize farming
5 technologies on per capita poverty outcomes[18]. Similarly to our study, they detected bias in the
6 distribution of covariates between groups before matching, indicating that accounting for bias
7 though PSM was important. In the field of CBR, PSM has been used to evaluate longitudinal CBR data
8 in India, looking at livelihood and health outcomes[28,29]. PSM was used to reduce the bias between
9 the CBR and non-CBR groups, with results showing that CBR participants had better health and
10 livelihood outcomes, and that these differences generally increased over time. As in our study, these
11 studies all showed bias between groups before matching which were reduced in the matched sample
12 after PSM. However, none of these studies presented their outcome results before matching for
13 comparison, so it cannot be determined if their final results were unaffected by matching as is the
14 case in our study.
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18 The results of the present study go against the anecdotal evidence that CBR has a positive influence
19 on the lives of people with disabilities[6,7,30]. Results from longitudinal data indicate that CBR has a
20 positive impact on receiving pensions, accessing paid jobs, accessing assistive devices, and personal-
21 practical autonomy, with the impact increasing over time[28]. An explanation for our results could be
22 that cross-sectional data do not allow causal inferences: results could simply point out that the
23 province with highest problems has been selected for receiving CBR interventions. Additionally, this
24 study focused on community inclusion - the ultimate goal of CBR - but when interpreting results it is
25 also important to consider the specific targets of the program being examined. Though CBR aims to
26 impact all aspects of the lives of people with disabilities, the program in Hué focuses specifically on
27 improving the health of people with disabilities through physiotherapist visits and strengthening
28 medical referral pathways. This could be a reason for the counter-intuitive results, and may
29 demonstrate the importance of matching the indicators used with the targets of programs.
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33 To our knowledge, this study is the first to implement the recently developed WHO CRB
34 Indicators[4]. The study highlights how important it is to collect standardized data in the field of CBR
35 in order to facilitate comparisons between groups and determine effectiveness of programs. One of
36 the main advantages of the CBR Indicators and their data collection strategy is that they are easy to
37 use in the field. The indicators allow for descriptive comparisons to be made easily, but in order for
38 indicators to be used appropriately it is important to go beyond these descriptive results using
39 inferential statistics. Furthermore, no single indicator or even a set of indicators is capable of
40 capturing all changes in dynamic settings. The use of indicators alone has the potential limitation of
41 collecting meaningless or misleading information,[31] and therefore they should be used as part of a
42 broad evaluation strategy, in combination with qualitative and participatory evaluations[30]. Another
43 way to reduce the limitations arising from indicator use is to continually test and re-assess the
44 indicators[31]. In the case of the CBR Indicators, a priority should be to do this in partnership with
45 communities in order to promote their uptake.
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50 The use of PSM as a method for analysis of cross-sectional data collected from the CBR Indicators is
51 conceptually strong, due to its ability to reduce bias due to confounding variables in observational
52 studies[9]. However, the methodological limitations of PSM also need to be considered. PSM
53 requires that each participant has a non-zero probability of receiving treatment, meaning only
54 people with disabilities can be included in the analysis. Due to this, one of the main advantages of
55 the CBR Indicators, namely the ability to use comparison individuals from the community, is lost[4].
56 Furthermore, PSM only controls for known covariates which means that there is a potential for bias if
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3 some covariates that affect the outcome are not included[9]. For example, in this study no data were
4 available on the ethnicity of participants, despite its known association with social disparities in
5 Vietnam[32]. Another such covariate in this study could be disability severity, although this was
6 partially adjusted for in both the participant selection, whereby all people with disabilities were
7 identified using the same government disability criteria, and further in the analysis through the
8 inclusion of the self-rated health covariate. Another limitation of PSM is that it leads to reduced
9 sample size which could limit generalizability, though this is partly addressed through the provided
10 sensitivity analysis. Further studies should look into additional statistical methods for analyzing the
11 results obtained from the CBR Indicators.
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14 Based on the present study, we recommend the further use and testing of the WHO CBR Indicators
15 to increase standardized data collection in the field of CBR. In accompaniment to increased data
16 collection, we recommend PSM as a method to reduce bias in cross-sectional CBR data analyses,
17 especially for international comparisons where differences between populations may be greater than
18 the within country differences observed in this study.
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21 **CONCLUSION**

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23 This study presents the first use of PSM as a method for analyzing cross-sectional CBR data. While
24 randomized and longitudinal data are ideal for evaluations, this type of data collection is often not
25 feasible in the field of CBR due to its high complexity and limited resources. The potential of using
26 PSM for analyzing cross-sectional CBR data was demonstrated, though further research should
27 investigate alternative inferential methods, such as cluster matching or adjusted regression, which
28 may be more suitable in allowing for the comparison of the differences between persons with and
29 without disabilities in line with the WHO CBR Indicators. We recommend that the questions and
30 indicators be continually reviewed, and that future cross-sectional CBR studies use PSM to reduce
31 bias when comparing groups.
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37 **FUNDING**

38
39 This research received no specific grant from any funding agency in the public, commercial or not-
40 for-profit sectors.
41

42 **COMPETING INTERESTS**

43
44 The authors declare no competing interests.
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46 **DATA SHARING**

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48 The data are owned by the World Health Organization (WHO). Data are available from the WHO for
49 researchers who meet the criteria for access to confidential data. Interested researchers can access
50 the data by the same means the authors accessed them, by contacting WHO under
51 disability@who.int. Statistical code is available from the corresponding author.
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54 **ACKNOWLEDGEMENTS**

55
56 The authors express gratitude to those from the Vietnamese Ministries and the local healthcare
57 workers who lent their knowledge and field experience. Special thanks go out to the interviewers
58
59

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3 who took the time to visit and speak with the participants; in Hue: Nguyen Thi Phung Diem, Nguyen
4 Van Hong, Thuong Thi Huong Giang, Thian Cong Chirh, and Nguyen Thi Ngoc Anh and in Hoa Binh: Ha
5 Thi Thoan, Vu Dury Hieu, Le Tleaal Hoa, Nguyen Quoc Dung, Le Vai Huy, and Nguyen Thanh.
6

7 **AUTHOR CONTRIBUTIONS**

8
9 Conceptualization: CM JW CS
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18 Writing – review & editing: CM JW CS DMT
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BMJ Open

Can propensity score matching be applied to cross-sectional data to evaluate Community-based Rehabilitation? Results of a survey implementing the World Health Organization's Community-based Rehabilitation Indicators in Vietnam

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-022544.R1
Article Type:	Research
Date Submitted by the Author:	12-Jul-2018
Complete List of Authors:	Mason, Catherine; LMU Munich, Department for Medical Information Processing, Biometry and Epidemiology (IBE) Sabariego, Carla; Ludwig-Maximilians University, Public Health and Health Services Research Thắng, Đoàn Mạnh ; Hoa Binh Department of Health Weber, Jörg; CBM eV
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Global health, Public health, Epidemiology
Keywords:	epidemiological methods, disability, social inequalities

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1 Can propensity score matching be applied to cross-sectional data to evaluate Community-
2 based Rehabilitation? Results of a survey implementing the World Health Organization's
3 Community-based Rehabilitation Indicators in Vietnam

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24 Keywords: disability, epidemiological methods, social inequalities

26 Word count: 4287

1 ABSTRACT

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Objectives: Community-Based Rehabilitation (CBR) is a multi-sectoral approach working to equalize opportunities and include people with disabilities in all aspects of life. The complexity of CBR and often limited resources lead to challenges when attempting to quantify its effectiveness, with randomization and longitudinal data rarely possible. Statistical methods, such as propensity score matching (PSM), offer an alternative approach to evaluate a treatment when randomization is not feasible. The aim of this study is to examine whether PSM can be an effective method to facilitate evaluations of results in CBR when data are cross-sectional.

Design: Cross-sectional survey

Setting and Participants: Data were collected using the World Health Organization's CBR Indicators in Vietnam, with treatment assignment (participating in CBR or not) determined by province of residence. 298 participants were selected through government records.

Results: PSM was conducted using one-to-one nearest neighbour method on ten covariates. Before matching, significant differences between groups were found for six of the ten covariates. PSM successfully adjusted for bias in all covariates in the matched sample (74 matched pairs). A paired t-test compared the outcome of "community inclusion" (a score based on selected indicators) between CBR and non-CBR participants both before and after matching, with CBR participants found to have significantly worse community inclusion scores (mean=17.86, SD=6.30, 95%CI 16.45-19.32) than non-CBR participants (mean=20.93, SD=6.16, 95%CI 19.50-22.35); $t(73)=3.068$, $p=0.001$. This result did not differ before and after matching.

Conclusion: PSM successfully reduced bias between groups, though its application did not affect the tested outcome. PSM should be considered when analyzing cross-sectional CBR data, especially for international comparisons where differences between populations may be greater.

Strengths and limitations of this study

- The complexity of CBR and often limited resources available in the field lead to challenges in research attempting to quantify its effectiveness and to a heavy reliance on non-randomized cross-sectional data, implying the need for statistical approaches, such as PSM, to account for these limitations.
- PSM attempts to mimic randomization by creating a sample of participants who received the treatment (CBR participants) that is comparable on all observed covariates to participants who did not receive the treatment (non-CBR participants).
- The potential of using PSM for analyzing cross-sectional CBR data was demonstrated, as biases detected in the distribution of covariates between groups before matching were successfully eliminated.
- One of the main advantages of the CBR Indicators, namely the ability to use comparison individuals without disability from the community is lost; as PSM requires that all participants have a non-zero probability of receiving treatment meaning only people with disabilities can be included.

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- 1 • PSM only controls for known covariates which means that there is a potential for bias if some
- 2 covariates that affect the outcome are not included.

For peer review only

1 INTRODUCTION

2 Community-Based Rehabilitation (CBR) is a multi-sectoral approach working to equalize
3 opportunities and include people with disabilities in all aspects of community life. It is broadly
4 defined as “a strategy within general community development for the rehabilitation, equalization of
5 opportunities and social inclusion of all people with disabilities”[1]. The wide scope of CBR is further
6 expanded through the various implementing stakeholders involved in CBR, including people with
7 disabilities themselves, their families and communities, and the relevant governmental and non-
8 governmental service sectors. It is due, at least in part, to this extensive definition that reliable and
9 internationally comparable data to monitor and evaluate CBR are scarce. In an effort to synthesize
10 global perspectives on CBR, the World Health Organization (WHO) developed their “Community-
11 Based Rehabilitation Guidelines” in 2010 which have since become accepted as a conceptual
12 framework for CBR[2]. With these guidelines, WHO emphasized the need for a common global
13 framework for monitoring CBR in line with the Convention on the Rights of Persons with Disability
14 (CRPD). With the launch of the global WHO CBR Indicators in 2015, there is now a standardized
15 approach to do this[3,4].

16
17 The complexity of CBR leads to challenges in research attempting to quantify its effectiveness[5-7].
18 Fully experimental studies with randomization are rarely possible for both ethical and practical
19 reasons, which inherently lead to limitations. The possibility of bias arises as the apparent difference
20 in an outcome between two treatment groups may depend on characteristics that affected whether
21 or not an individual received a given treatment, instead of being an actual effect of the treatment.
22 For this reason there has been a recent emphasis on so-called natural experiments, where a range of
23 primarily statistical approaches are used to evaluate a treatment or intervention when
24 randomization is not feasible[8]. One such approach is propensity score matching (PSM).

25 PSM was first presented in 1983 by Rosenbaum and Rubin as a method to reduce bias due to
26 confounding variables in observational studies[9]. It attempts to mimic randomization by creating a
27 sample of participants who received the treatment that is comparable on all observed covariates to
28 participants who did not receive the treatment. This effectively creates an experimental dataset
29 where the comparison group is, on average, equivalent to individuals in the exposed group on all
30 observed covariates[10-12]. A systematic review comparing 21 PSM studies to 63 RCTs on
31 therapeutic interventions for acute coronary syndromes found that PSM produced more extreme
32 treatment effect estimates when compared with those from RCTs, although these differences were
33 rarely statistically significant[13]. A similar comparison including 20 propensity-score-based studies
34 matched to RCT results was conducted examining critical care medicine and found that propensity-
35 score-based studies report less beneficial effects of treatment in comparison to RCTs[14]. Despite
36 some shortcomings, PSM provides a method for evaluating complex interventions where
37 randomization is not possible.

38 PSM has been increasingly used in various research fields, including Public Health, to evaluate
39 complex interventions[15]. CBR is considered a complex intervention, and data collection in the field
40 is further hindered by low resources making quantitative longitudinal data collection infeasible and
41 rarely done[6,7,16,17]. This implies that data analysis in the field of CBR relies heavily on cross-
42 sectional data. PSM has already been successfully applied to cross-sectional data[18,19]. Therefore,
43 the main objective of this paper is to examine whether PSM can be an effective method to facilitate
44 evaluations of results in CBR when data are cross-sectional. Data used in the present study were

1 collected using the WHO CBR Indicators in Vietnam in 2016 with the assignment of persons to the
2 treatment (CBR participants) and non-treatment group (non-CBR participants) determined by
3 province of residence. PSM will be conducted on the outcome of *community inclusion* of people with
4 disabilities, the ultimate goal of CBR in strong alignment with the CRPD, using a sum score of WHO
5 CBR social indicators and an empowerment indicator.

6 7 **METHODS**

8 **Data Collection**

9 Data collection was conducted using the survey questionnaire accompanying the WHO CBR
10 Indicators[3]. These indicators examine differences in health, education, social life, livelihood and
11 empowerment between people with disabilities and other community members. There are two
12 subsets of indicators: base indicators which are broad and should be used in all data collection
13 activities to ensure comparability, and supplementary indicators which can provide more specific
14 coverage, and can be selected depending on the specific CBR goals and strategies of a program. The
15 indicators and corresponding questions used in this paper are presented in table 1.

16 Data collection involved a multi-site cross-sectional survey in 2016 in two Vietnamese provinces:
17 Huế, where CBR is fully implemented and all districts have CBR coverage through government
18 implementation and through non-governmental organizations' (NGO) activities; and Hòa Bình, where
19 CBR is not implemented by either government or NGOs. The Huế CBR program began in 2009 in
20 cooperation with the Huế Rehabilitation Hospital. The program focused mainly on activities to
21 increase capacity building for CBR workers, not only in terms of rehabilitation skills, but also working
22 to improve their counselling and networking skills. The other focus of the program was to strengthen
23 referral pathways for people with disabilities so that they could be connected with other existing
24 services in the province, such as schools with teachers who were trained to support students with
25 disabilities and vocational training centers. An Android mobile phone application (app), available
26 from WHO for the CBR Indicators, was used to collect data during interviews (app free to download
27 at:

28 <http://play.google.com/store/apps/details?id=com.universaltools.whocbrsurvey&hl=en>).

29
30 People with disabilities were identified prior to the survey by government records. In both provinces
31 a team of five local health care workers were trained by the lead researcher (CM) over two days on
32 how to conduct interviews using the survey questions and the app. Data collection was supervised by
33 CM. Data were collected during face-to-face interviews with data recorded anonymously. All
34 respondents were informed of the purpose of the study, and then provided verbal (Huế) or written
35 consent (Hòa Bình). In Huế the decision to provide verbal rather than written consent was justified
36 since requiring written consent would embarrass illiterate participants, leading to a decreased
37 willingness to answer further questions truthfully. In instances when the respondent had cognitive
38 limitations that prevented them from being interviewed, or if the respondent was a minor, a proxy
39 interview with a family member was performed. Ethical approval was obtained through the Ludwig-
40 Maximilians-Universität Munich Ethics Commission and by the local provincial Ministries of Health.

41 **Variables**

42 *Outcome Variable*

To measure community inclusion, a sum score was created from the social base and supplementary questions, with the addition of the base question from empowerment. These questions all used the same response scale of 1(*Not at all*) to 5(*Completely*) with the final sum score ranging from 4 to 33, with higher scores indicating higher levels of inclusion (Table 1).

Table 1. WHO CBR Indicators and questions used to measure them. Base indicators are shown in bold. The response option for all questions ranged from 1 (Not at all) to 5 (Completely).

Component	Indicator	Survey Question
Social	% of people with disability that feel valued as individuals by members of their community	Do you feel that other people respect you? For example, do you feel that others value you as a person and listen to what you have to say?
	% of people with disability who make their own decisions about the personal assistance they need	Do you get to make decisions about the personal assistance that you need (who assists you, what type of assistance, when to get assistance)?
	% of people with disability make their own decisions about their personal relationships	Do you get to make your own decisions about your personal relationships, such as friends and family?
	% of people with disability who participate in artistic, cultural or religious activities	Do you get to participate in artistic, cultural or religious activities?
	% of people with disability who participate in mainstream recreational, leisure and sports activities	Do you get to participate in community recreational, leisure and sports activities?
	% of people with disability who know their legal rights	To what extent do you know your legal rights?
Empowerment	% of people with disability who make informed choices and decisions	Do you get to make the big decisions in your life? For example, deciding who to live with, where to live, or how to spend your money?

Matching Variables

Matching variables were those available from the WHO CBR Indicators, and were selected based on their theoretical association with community inclusion, primarily using CBR Guidelines[2]. Data on *age* and *gender* were collected. Age was collected in categories (0-5, 6-12, 13-17, 18-24, 25-44, 45-64, and 65+) which were dichotomized for the analysis[20]. Though data on disability severity were not available, *general health status* was used as a proxy, using the question “*How would you rate your health today?*”[21]. A variable for *socio-economic status* (SES) was created using a sum score based on the questions “*What is the highest level of education you have achieved or are working to achieve?*” and “*Do you have enough money to meet your needs?*”. The first question is commonly used in SES variable creation, and the second question targets wealth[22,23]. The variable *province of residence* corresponded to CBR coverage (no coverage in Hòa Bình, full CBR coverage in Huế). To account for economic differences between the provinces that might not be captured by SES, the covariate *receiving social protection* (such as for loss of income through old age, sickness or disability) was included. Covariates of *financial awareness* (knowing how to get financial services or social protection if needed), *having access to health services when needed*, and *having access to rehabilitation services when needed* were also included. A proxy for autonomy was captured through the covariates of *being involved in decision making regarding medical treatment* and *participating in a self-help group if desired* (see Supplementary Table). Seeing as the CBR program in Huế focused on increasing referral pathways within the medical and education sectors, the questions derived from the education component and many from the medical component were not included as matching variables, since including covariates associated with CBR participation but not with community inclusion decrease model precision[24].

1 *Missing Data*

2 Missing data were low (2.25%). Multiple imputation (five imputations) using fully conditional
3 specification (MICE package [25] in R Studio Version 0.99.903) was used to replace missing data.
4

5 **Analysis**

6 *Matching on the Propensity Score*

7 The number of treated and untreated participants were similar (difference of n=4). Therefore,
8 participants were matched using one-to-one nearest neighbour technique, which matched each
9 treated unit to one control that was closest using calipers of width equal to 0.25 of the standard
10 deviation (SD) of the logit of the estimated propensity score without iteration[26]. This implies that
11 for a given treated participant, all the untreated participants are identified whose scores are within
12 this specified distance and then the best match is formed. If no match falls within this distance the
13 participant is excluded. Participants were matched on ten covariates (see *Matching Variables*).

14 *Balance Diagnostics*

15 Baseline comparisons between the covariates were conducted before and after matching. Balance
16 diagnosis was performed using the standardized difference method, which compares the difference
17 in means of each covariate in units of the pooled standard deviation before and after matching[12].
18 Successful matching is indicated when the absolute standardized differences of means is less than
19 0.25[27].

20 *Comparing Groups*

21 For the community inclusion outcome, data matched on the ten covariates were compared using a
22 paired t-test[28]. Bootstrapping was performed (1000 samples) in order to produce 95% confidence
23 intervals (CI), which has been shown to account for uncertainty in the matching procedure[20].

24 A sensitivity analysis was performed using the Rosenbaum Bounds for Hodges-Lehmann Point
25 Estimate to assess how robust the findings were to hidden bias due to unobserved covariates
26 ('rbounds' package [29] in R Studio Version 0.99.903). The maximum Gamma (the odds of differential
27 assignment to treatment due to unobserved factors) was set to 2 with increments of 0.1 to test at
28 which point the between group differences are no longer robust[29].

29 Data cleaning was performed using SPSS version 23 (copyright IBM Corporation). PSM was
30 performed in R Studio (Version 0.99.903) using the 'MatchIt' package[30].
31

32 **Patient and Public Involvement**

33 Participants were not directly involved in the development of the research question, study design,
34 recruitment or conduct of the study. However, in the province of Hué (where CBR is implemented)
35 participants are continually involved in the development of the CBR program, as CBR is participatory
36 in nature. It was through their motivation – stemming from the need to prove to the national
37 government and international donors that their intervention has an impact in order to receive funds
38 – that the survey was conducted in the first place. A study report was submitted to the Hué and Hòa

1 Binh Ministries of Health which presented simple numeric and graphic descriptive findings which
2 were to be communicated to participants.

4 RESULTS

5 Data were available from 298 participants. In Huế, 575 people with disabilities were identified by
6 government records and 147 were included, while in Hòa Bình 375 people were identified by
7 government records and 151 were included (sample size calculated using an alpha significance level
8 of 0.05 and power of 90%). Included participants were randomly selected from the complete list.
9 After the random selection, each interviewer was assigned a group of selected participants based on
10 their geographic location. Of the randomly selected participants, one in Hòa Bình could not be
11 contacted so another participant was selected. In both provinces none of the invited participants
12 refused participation. Males comprised 153(51.3%) of the participants, with a modal age group of 45-
13 64(28.9%) (see table 2 for further descriptives).

14 Before matching CBR participants had higher health status, were more likely to participate in a self-
15 help group, more financially aware and more likely to be receiving social protection while they had
16 worse access to rehabilitation services. Some age differences were also noted (Table 2). In the
17 unmatched sample the absolute standardized difference across the 10 covariates ranged from 0.008
18 to 1.008 indicating bias.

19 When CBR participants were matched with non-CBR participants on the logit of the specified
20 propensity score model, 74 matched pairs were formed. This meant that 49.7% of CBR participants
21 were successfully matched to a control. PSM was successful in reducing bias between the covariates
22 in the matched sample, as the standardized differences ranged from 0 to 0.147 with all values falling
23 below the threshold value of 0.25[27] (Table 2).

24 **Table 2.** Baseline characteristics of CBR participants and non-CBR participants in the unmatched and
25 matched samples. Absolute standardized differences of means are shown, with differences
26 exceeding the threshold of 0.25 indicated in bold.

Variable		Unmatched Sample			Matched Sample		
		Mean No CBR (n=151)	Mean With CBR (n=147)	Std. dif. of means	Mean No CBR (n=74)	Mean With CBR (n=74)	Std. dif. of means
Age	0-5	11 (7.2%)	6 (4.1%)	0.161	3 (4.1%)	5 (6.8%)	0.136
	6-12	19 (12.6%)	11 (7.5%)	0.193	7 (9.5%)	5 (6.8%)	0.102
	13-17	4 (2.6%)	6 (4.1%)	0.072	2 (2.7%)	1 (1.4%)	0.068
	18-24	12 (7.9%)	12 (8.2%)	0.008	7 (9.5%)	7 (9.5%)	0.000
	25-44	49 (32.5%)	32 (21.8%)	0.258	23 (31.1%)	22 (29.7%)	0.033
	45-64	42 (27.8%)	44 (29.9%)	0.046	21 (28.4%)	26 (35.1%)	0.147
	65+	14 (9.3%)	36 (24.5%)	0.353	11 (14.9%)	8 (10.8%)	0.094
Gender (male)		80 (53.0%)	73 (50.0%)	0.066	37 (50.0%)	42 (56.8%)	0.135
SES (range 1-10)		3.74±1.32	3.91±1.30	0.235	3.65±1.45	3.67±1.42	0.020
Health status (range 1-5)		2.89±0.77	3.37±0.70	0.683	3.05±0.75	3.14±0.65	0.115
Receiving social protection		74 (49.0%)	117 (79.6%)	1.008	48 (64.9%)	52 (70.3%)	0.141
Access to health services		132 (87.4%)	126 (85.7%)	0.048	66 (89.2%)	66 (89.2%)	0.000
Access to rehabilitation services		128 (84.8%)	123 (83.7%)	0.263	29 (39.2%)	31 (41.9%)	0.054
Self-help group		63 (41.7%)	75 (51.0%)	0.396	31 (41.9%)	32 (43.2%)	0.027
Financial awareness		73 (48.3%)	122 (83.0%)	0.789	51 (68.9%)	55 (74.3%)	0.134
Involved in treatment		47 (31.1%)	65 (44.2%)	0.137	65 (87.8%)	65 (87.8%)	0.000

decisions						
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1 Note: continuous variables are presented as means \pm standard deviation; dichotomous variables are presented
2 as N(%)

3 To test whether PSM affected the pre-defined outcome of community inclusion, the difference
4 between groups before and after matching were assessed: similar significant differences were found.
5 In the matched sample, CBR participants had worse community inclusion scores (mean=17.86,
6 SD=6.30, 95%CI 16.45-19.32) than non-CBR participants (mean=20.93, SD=6.16, 95%CI 19.50-22.35);
7 $t(73)=3.068$, $p=0.001$. The sensitivity analysis corroborated the results, showing that CBR participants
8 had a median difference in community inclusion score 3.5 points lower than non-CBR participants
9 ($\text{Gamma}=0$). When the Gamma value was increased to 2, the upper and lower bounds did not include
10 zero indicating robust results[29]. In a further sensitivity analysis, to ensure that the covariate of
11 "access to rehabilitation" did not bias the model by being more strongly associated with receiving
12 CBR rather than with the outcome of community inclusion, the model was run excluding this
13 variable. The new model resulted in 75 matched pairs with all standardized differences falling below
14 the threshold. The results of the t-test did not differ from the model including access to
15 rehabilitation; CBR participants had worse community inclusion scores (mean=18.11, SD=5.981,
16 95%CI 16.72-19.47) than non-CBR participants (mean=21.17, SD=6.381, 95%CI 19.67-22.60);
17 $t(74)=3.310$, $p=0.0014$.

18 Overall, the results did not differ from the results before PSM: community inclusion for participants
19 with CBR (mean=18.61, SD=5.38) and without CBR (mean=20.64, SD=6.49); $t(296)=2.935$, $p=0.004$
20 using an independent t-test.

21

22 DISCUSSION

23 To our knowledge, this study presents the first use of PSM as a method for analyzing cross-sectional
24 data in the field of CBR. The study analyzed data collected using the WHO CBR Indicators, and found
25 that community inclusion scores of CBR participants were significantly lower than those of non-CBR
26 participants after PSM. Despite bias being detected in the distribution of covariates between groups
27 before matching, the results before PSM did not significantly differ from those after. We conclude
28 that PSM can be successfully applied to cross-sectional CBR data, though in this case the bias
29 reduction provided by PSM did not affect the tested outcome.

30 PSM has been applied only to longitudinal CBR data so far, but PSM studies using cross-sectional data
31 are available from other fields. These studies had similar results in terms of the methodological
32 success of PSM, but unlike our study they had final outcomes in line with their hypotheses. One such
33 example is the study from Jalan and Ravallion which examines the effect of an employment-based
34 poverty reduction program on income gain, accounting for pre-intervention and foregone
35 income[19]. Through the trial of three PSM methods, they were able to reduce the differences
36 between the two populations and to demonstrate the effectiveness of the program. Another such
37 example is the study from Becerril and Abdulai showing the positive impact of new maize farming
38 technologies on per capita poverty outcomes[18]. Similarly to our study, they detected bias in the
39 distribution of covariates between groups before matching, indicating that accounting for bias
40 though PSM was important. In the field of CBR, PSM has been used to evaluate longitudinal CBR data
41 in India, looking at livelihood and health outcomes[31,32]. PSM was used to reduce the bias between
42 the CBR and non-CBR groups, with results showing that CBR participants had better health and

1
2
3 1 livelihood outcomes, and that these differences generally increased over time at both four years and
4 2 seven years. In our study, data was collected seven years after the program began, which would
5 3 make the timing comparable and it is therefore plausible that the effect of CBR in our study could
6 4 already be quantifiable. As in our study, these studies all showed bias between groups before
7 5 matching which were reduced in the matched sample after PSM. However, none of these studies
8 6 presented their outcome results before matching for comparison, so it cannot be determined if their
9 7 final results were unaffected by matching as is the case in our study.

11
12 8 The results of the present study go against the anecdotal evidence that CBR has a positive influence
13 9 on the lives of people with disabilities[6,7,33]. Results from longitudinal data indicate that CBR has a
14 10 positive impact on receiving pensions, accessing paid jobs, accessing assistive devices, and personal-
15 11 practical autonomy, with the impact increasing over time[31]. An explanation for our results could be
16 12 that cross-sectional data do not allow causal inferences: results could simply point out that the
17 13 province with highest problems has been selected for receiving CBR interventions. While the cross-
18 14 sectional data collected in this study represent the first quantitative data from the region and
19 15 therefore an important foundation for future work, the results emphasizes the general need for
20 16 further collection and publication of CBR data, especially longitudinal data. Additionally, this study
21 17 focused on community inclusion - the ultimate goal of CBR - but when interpreting results it is also
22 18 important to consider the specific targets of the program being examined. Though CBR aims to
23 19 impact all aspects of the lives of people with disabilities to increase community inclusion, the
24 20 program in Hué does not directly target community inclusion. The program focuses on increasing the
25 21 capacity of CBR workers and on strengthening referral pathways with the medical and educational
26 22 sectors. Through these activities the community inclusion of people with disabilities should improve
27 23 over time, but since community inclusion was not the direct target of the program, the community
28 24 inclusion effects might only appear after a longer period, which could be a reason for the counter-
29 25 intuitive results. Therefore, when assessing a program in its early stages, it may be more important to
30 26 match the indicators used with the specific targets of programs.

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36 27 To our knowledge, this study is the first to implement the recently developed WHO CRB
37 28 Indicators[4]. The study highlights how important it is to collect standardized data in the field of CBR
38 29 in order to facilitate comparisons between groups and determine effectiveness of programs. One of
39 30 the main advantages of the CBR Indicators and their data collection strategy is that they are easy to
40 31 use in the field. The indicators allow for descriptive comparisons to be made easily, but for indicators
41 32 to be used appropriately it is important to go beyond these descriptive results using inferential
42 33 statistics. Furthermore, no single indicator or even a set of indicators is capable of capturing all
43 34 changes in dynamic settings. The use of indicators alone has the potential limitation of collecting
44 35 meaningless or misleading information,[34] and therefore they should be used as part of a broad
45 36 evaluation strategy, in combination with qualitative and participatory evaluations[33]. Another way
46 37 to reduce the limitations arising from indicator use is to continually test and re-assess the
47 38 indicators[34]. In the case of the CBR Indicators, a priority should be to do this in partnership with
48 39 communities and people with disabilities in order to promote their uptake.

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52 40 The use of PSM as a method for analysis of cross-sectional data collected from the CBR Indicators is
53 41 conceptually strong, due to its ability to reduce bias due to confounding variables in observational
54 42 studies[9]. However, the methodological limitations of PSM also need to be considered. PSM
55 43 requires that each participant has a non-zero probability of receiving treatment, meaning only
56 44 people with disabilities can be included in the analysis. Due to this, one of the main advantages of

1 the CBR Indicators, namely the ability to use comparison individuals from the community, is lost[4].
2 Furthermore, PSM only controls for known covariates which means that there is a potential for bias if
3 some covariates that affect the outcome are not included[9]. For example, in this study no data were
4 available on the ethnicity of participants, despite its known association with social disparities in
5 Vietnam[35]. Another such covariate in this study could be disability severity, although this was
6 partially adjusted for in both the participant selection, whereby all people with disabilities were
7 identified using the same government disability criteria, and further in the analysis through the
8 inclusion of the self-rated health covariate. Another limitation of PSM is that it leads to reduced
9 sample size which could limit generalizability, though this is partly addressed through the provided
10 sensitivity analysis. The reduced sample size also increases the risk of type II error[36], but the
11 sample size of this study met the commonly recommended minimum sample size of $10(p + 1)$, where
12 p is the number of matching variables[37]. This study presents a starting point to encourage the
13 generation of quantitative CBR research and demonstrates one possible method for reducing bias
14 when analyzing cross-sectional CBR data. Further studies should look into additional statistical
15 methods for analyzing the results obtained from the CBR Indicators.

16 Based on the present study, we recommend the further use and testing of the WHO CBR Indicators
17 to increase standardized data collection in the field of CBR. In accompaniment to increased data
18 collection, we recommend PSM as a method to reduce bias in cross-sectional CBR data analyses,
19 especially for international comparisons where differences between populations may be greater than
20 the within country differences observed in this study. Since using cross-sectional data presents
21 limitations even after adjusting for bias, we also emphasize the need for future longitudinal data
22 collection in order to assess effectiveness in the field of CBR.

23 **CONCLUSION**

24 This study presents the first use of PSM as a method for analyzing cross-sectional CBR data. While
25 randomized and longitudinal data are ideal for evaluations, cross-sectional data presents the
26 advantage of being more feasible to collect and thereby providing an essential foundation to
27 generate hypotheses and perform further studies. Therefore, it is essential that appropriate
28 statistical methods are applied to capitalize on available data. The potential of using PSM for
29 analyzing cross-sectional CBR data was demonstrated, though further research should investigate
30 alternative inferential methods, such as cluster matching or adjusted regression, which may be more
31 suitable in allowing for the comparison of the differences between persons with and without
32 disabilities in line with the WHO CBR Indicators. We recommend that the questions and indicators be
33 continually reviewed, and that future cross-sectional CBR studies use PSM to reduce bias when
34 comparing groups.

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36 **FUNDING**

37 This research received no specific grant from any funding agency in the public, commercial or not-
38 for-profit sectors.

39 **COMPETING INTERESTS**

40 The authors declare no competing interests.

1 DATA SHARING

2 The data are owned by the World Health Organization (WHO). Data are available from the WHO for
3 researchers who meet the criteria for access to confidential data. Interested researchers can access
4 the data by the same means the authors accessed them, by contacting WHO under
5 disability@who.int. Statistical code is available from the corresponding author.

6 ACKNOWLEDGEMENTS

7 The authors express gratitude to those from the Vietnamese Ministries and the local healthcare
8 workers who lent their knowledge and field experience. Special thanks go out to the interviewers
9 who took the time to visit and speak with the participants; in Huế: Nguyen Thi Phung Diem, Nguyen
10 Van Hong, Thuong Thi Huong Giang, Thian Cong Chirh, and Nguyen Thi Ngoc Anh and in Hoa Binh: Ha
11 Thi Thoan, Vu Dury Hieu, Le Tleaal Hoa, Nguyen Quoc Dung, Le Vai Huy, and Nguyen Thanh.

12 AUTHOR CONTRIBUTIONS

13 Conceptualization: CM JW CS
14 Investigation: CM JW
15 Methodology: CM JW CS
16 Data curation: CM DMT
17 Formal analysis: CM
18 Project administration: CM JW CS
19 Resources: CM JW CS DMT
20 Supervision: CM DMT CS JW
21 Writing – original draft: CM CS JW
22 Writing – review & editing: CM JW CS DMT

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Supplementary Table. The WHO CBR Survey questions, response options and analysis categories for the matching variables.

Variable	Survey Question and Response Options	Analysis Categories
Gender	Record the gender of the selected participant	Male=1, Female=0
Age	How old are you?	0-5yrs=1; 6-12yrs=2; 13-17yrs=3; 18-24yrs=4; 25-44yrs=5; 45-64yrs=6; 65+yrs=7
Education Level (for creation of SES)	What is the highest level of education you have achieved, or are working to achieve? <i>1=No schooling or never completed any grade; 2=Elementary education; 3=Vocational education; 4=Professional training; 5=Secondary school; 6=College; 7=University; 8=Post-graduate studies; 9=Other</i>	If respondent answered 1: score=0 If respondent answered 2: score=1 If respondent answered 3,4,5: score=2* If respondent answered 6,7,8: score=3
Employment Grade	What is your current working situation? <i>1=Not working and looking for work; 2=Not working for wages and not looking for paid work; 3=Working for wages or salary with an employer; 4=Working for wages, but currently on sick leave; 5=Self-employed or own-account worker; 6=Working as unpaid family member; 7=Retired because of the health condition; 8=Retired because of age; 9=Early retirement; 10=Other</i>	If respondent answered 1: score=0 If respondent answered 6: score=1 If respondent answered 2,3,4,5,7,8,9: score=2 If respondent answered 10: score=missing
Health Status (for creation of SES)	In general, how would you rate your health today? <i>1 = Very good; 2 = Good; 3 = Neither poor nor good; 4 = Poor; 5 = Very poor</i>	Inverted
Received needed medical care	In the last 12 months, has there been a time when you needed health care but did not get that care? <i>1 = Yes; 2 = No; 3 = No need for health care in the past 12 months</i>	If respondent answered 1: score=0 If respondent answered 2 or 3: score=1
Involved in making treatment decisions	On your last visit to a health care provider, to what extent were you involved in making decisions for your treatment? <i>1 (Not at all); 2; 3; 4; 5 (Completely)</i>	No transformation
Received needed rehabilitation services	In the last 12 months, has there been a time when you needed rehabilitation services, such as physical, occupational, or speech therapy, but did not get those services? <i>1 = Yes; 2 = No; 3 = No need for rehabilitation services in the past 12 months</i>	If respondent answered 1: score=0 If respondent answered 2 or 3: score=1
Aware of financial services	Do you know how to get financial services such as credit, insurance, grants, and savings programs? <i>1 = Yes; 2 = No</i>	If respondent answered 1: score=1 If respondent answered 2: score=0
Receive social protection	Do you currently benefit from any social protection program, such as loss of income through old age, sickness or disability? <i>1 = Yes; 2 = No</i>	If respondent answered 1: score=1 If respondent answered 2: score=0
Participation in self-help group	Are you a member of a self-help group? <i>1=Yes; 2=No, but I would like to; 3=No, I don't want to</i>	If respondent answered 1 or 3: score=1 If respondent answered 2: score=0

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract Pg 1, 1-3 (b) Provide in the abstract an informative and balanced summary of what was done and what was found Pg 2, 3-28
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported Pg 4, 2-39
Objectives	3	State specific objectives, including any prespecified hypotheses Pg 4, 40- pg 5, 3
Methods		
Study design	4	Present key elements of study design early in the paper Pg 5, 7-8; 14
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection Pg 5, 14-37
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants Pg 5, 27; pg 8, 5 (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable Pg 5, 40- pg 6, 23; Supplementary Table
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group Pg 5, 7-13
Bias	9	Describe any efforts to address potential sources of bias Pg 7, 20-27 → The analysis uses PSM, a method to reduce bias
Study size	10	Explain how the study size was arrived at Pg 8, 2-5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why Pg 5, 40- pg 6, 23; Supplementary Table
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding

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3 (b) Describe any methods used to examine subgroups and interactions

4 (c) Explain how missing data were addressed

5 Pg 7, 1-2

6 (d) *Cohort study*—If applicable, explain how loss to follow-up was addressed

7 *Case-control study*—If applicable, explain how matching of cases and controls was
8 addressed

9 *Cross-sectional study*—If applicable, describe analytical methods taking account of
10 sampling strategy

11 (e) Describe any sensitivity analyses

12 Pg 7, 23-27; pg 9, 8-14

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Results

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed Pg 8, 2-4 (b) Give reasons for non-participation at each stage Pg 8, 7-8 (c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders Pg 8, 9-10, 21-25 (b) Indicate number of participants with missing data for each variable of interest Pg 7, 1-2 (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures Pg 5, 40- pg 6, 2
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included Pg 9, 1-5 (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses Pg 9, 5-14
Discussion		
Key results	18	Summarise key results with reference to study objectives Pg 9, 20-26
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias Pg 10, 7-22; 29-33; pg 10, 38- pg 11, 1-7
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence Pg 11, 8-18
Generalisability	21	Discuss the generalisability (external validity) of the study results Pg 11, 4-6
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based Pg 11, 32-33

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2 *Give information separately for cases and controls in case-control studies and, if applicable, for exposed and
3 unexposed groups in cohort and cross-sectional studies.
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5 **Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and
6 published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely
7 available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at
8 <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is
9 available at www.strobe-statement.org.
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BMJ Open

Can propensity score matching be applied to cross-sectional data to evaluate Community-based Rehabilitation? Results of a survey implementing the World Health Organization's Community-based Rehabilitation Indicators in Vietnam

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2018-022544.R2
Article Type:	Research
Date Submitted by the Author:	07-Nov-2018
Complete List of Authors:	Mason, Catherine; LMU Munich, Department for Medical Information Processing, Biometry and Epidemiology (IBE) Sabariego, Carla; Ludwig-Maximilians University, Public Health and Health Services Research Thắng, Đoàn Mạnh ; Hoa Binh Department of Health Weber, Jörg; CBM eV
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Global health, Public health, Epidemiology
Keywords:	epidemiological methods, disability, social inequalities

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4 2 based Rehabilitation? Results of a survey implementing the World Health Organization's
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32 30
33 31 Keywords: disability, epidemiological methods, social inequalities
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36 34 Word count: 3787
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1 ABSTRACT

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1 **Objectives:** Community-Based Rehabilitation (CBR) is a multi-sectoral approach working to equalize opportunities and include people with disabilities in all aspects of life. The complexity of CBR and often limited resources lead to challenges when attempting to quantify its effectiveness, with randomization and longitudinal data rarely possible. Statistical methods, such as propensity score matching (PSM), offer an alternative approach to evaluate a treatment when randomization is not feasible. The aim of this study is to examine whether PSM can be an effective method to facilitate evaluations of results in CBR when data are cross-sectional.

11 **Design:** Cross-sectional survey

13 **Setting and Participants:** Data were collected using the World Health Organization's CBR Indicators in Vietnam, with treatment assignment (participating in CBR or not) determined by province of residence. 298 participants were selected through government records.

17 **Results:** PSM was conducted using one-to-one nearest neighbour method on ten covariates. In the unmatched sample, significant differences between groups were found for six of the ten covariates. PSM successfully adjusted for bias in all covariates in the matched sample (74 matched pairs). A paired t-test compared the outcome of "community inclusion" (a score based on selected indicators) between CBR and non-CBR participants for both the matched and unmatched samples, with CBR participants found to have significantly worse community inclusion scores (mean=17.86, SD=6.30, 95%CI 16.45-19.32) than non-CBR participants (mean=20.93, SD=6.16, 95%CI 19.50-22.35); $t(73)=3.068$, $p=0.001$. This result did not differ between the matched and unmatched samples.

26 **Conclusion:** PSM successfully reduced bias between groups, though its application did not affect the tested outcome. PSM should be considered when analyzing cross-sectional CBR data, especially for international comparisons where differences between populations may be greater.

30 **Strengths and limitations of this study**

- 31 • The complexity of CBR and often limited resources available in the field lead to challenges in research attempting to quantify its effectiveness and to a heavy reliance on non-randomized cross-sectional data, implying the need for statistical approaches, such as PSM, to account for these limitations.
- 32 • PSM attempts to mimic randomization by creating a sample of participants who received the treatment (CBR participants) that is comparable on all observed covariates to participants who did not receive the treatment (non-CBR participants).
- 33 • The potential of using PSM for analyzing cross-sectional CBR data was demonstrated, as biases detected in the distribution of covariates between groups in the unmatched sample were successfully eliminated.
- 34 • One of the main advantages of the CBR Indicators, namely the ability to use comparison individuals without disability from the community is lost; as PSM requires that all participants have a non-zero probability of receiving treatment meaning only people with disabilities can be included.

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- 1 • PSM only controls for known covariates which means that there is a potential for bias if some
- 2 covariates that affect the outcome are not included.

For peer review only

1 INTRODUCTION

2 Community-Based Rehabilitation (CBR) is a multi-sectoral approach working to equalize opportunities
3 and include people with disabilities in all aspects of community life. It is broadly defined as “a strategy
4 within general community development for the rehabilitation, equalization of opportunities and social
5 inclusion of all people with disabilities”[1]. The wide scope of CBR is further expanded through the
6 various implementing stakeholders involved in CBR, including people with disabilities themselves, their
7 families and communities, and the relevant governmental and non-governmental service sectors. It is
8 due, at least in part, to this extensive definition that reliable and internationally comparable data to
9 monitor and evaluate CBR are scarce. In an effort to synthesize global perspectives on CBR, the World
10 Health Organization (WHO) developed their “Community-Based Rehabilitation Guidelines” in 2010
11 which have since become accepted as a conceptual framework for CBR[2]. With these guidelines, WHO
12 emphasized the need for a common global framework for monitoring CBR in line with the Convention
13 on the Rights of Persons with Disability (CRPD). With the launch of the global WHO CBR Indicators in
14 2015, there is now a standardized approach to do this[3,4].

15
16 The complexity of CBR leads to challenges in research attempting to quantify its effectiveness[5-7].
17 Fully experimental studies with randomization are rarely possible for both ethical and practical
18 reasons, which inherently lead to limitations. The possibility of bias arises as the apparent difference
19 in an outcome between two treatment groups may depend on characteristics that affected whether
20 or not an individual received a given treatment, instead of being an actual effect of the treatment. For
21 this reason there has been a recent emphasis on so-called natural experiments, where a range of
22 primarily statistical approaches are used to evaluate a treatment or intervention when randomization
23 is not feasible[8]. One such approach is propensity score matching (PSM).

24 PSM was first presented in 1983 by Rosenbaum and Rubin as a method to reduce bias due to
25 confounding variables in observational studies[9]. It attempts to mimic randomization by creating a
26 sample of participants who received the treatment that is comparable on all observed covariates to
27 participants who did not receive the treatment. This effectively creates an experimental dataset where
28 the comparison group is, on average, equivalent to individuals in the exposed group on all observed
29 covariates[10-12]. A systematic review comparing 21 PSM studies to 63 RCTs on therapeutic
30 interventions for acute coronary syndromes found that PSM produced more extreme treatment effect
31 estimates when compared with those from RCTs, although these differences were rarely statistically
32 significant[13]. A similar comparison including 20 propensity-score-based studies matched to RCT
33 results was conducted examining critical care medicine and found that propensity-score-based studies
34 report less beneficial effects of treatment in comparison to RCTs[14]. Despite some shortcomings, PSM
35 provides a method for evaluating complex interventions where randomization is not possible.

36 PSM has been increasingly used in various research fields, including Public Health, to evaluate complex
37 interventions[15]. CBR is considered a complex intervention, and data collection in the field is further
38 hindered by low resources making quantitative longitudinal data collection infeasible and rarely
39 done[6,7,16,17]. This implies that data analysis in the field of CBR relies heavily on cross-sectional data.
40 PSM has already been successfully applied to cross-sectional data[18,19]. Therefore, the main
41 objective of this paper is to examine whether PSM can be an effective method to facilitate evaluations
42 of results in CBR when data are cross-sectional. Data used in the present study were collected using
43 the WHO CBR Indicators in Vietnam in 2016 with the assignment of persons to the treatment (CBR
44 participants) and non-treatment group (non-CBR participants) determined by province of residence.

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3 1 PSM will be conducted on the outcome of *community inclusion* of people with disabilities, the ultimate
4 2 goal of CBR in strong alignment with the CRPD, using a sum score of WHO CBR social indicators and an
5 3 empowerment indicator.
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8 4
9 5 **METHODS**

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11 6 **Data Collection**
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14 8 Data collection was conducted using the survey questionnaire accompanying the WHO CBR
15 9 Indicators[3]. These indicators examine differences in health, education, social life, livelihood and
16 10 empowerment between people with disabilities and other community members. There are two
17 11 subsets of indicators: base indicators which are broad and should be used in all data collection activities
18 12 to ensure comparability, and supplementary indicators which can provide more specific coverage, and
19 13 can be selected depending on the specific CBR goals and strategies of a program. The indicators and
20 14 corresponding questions used in this paper are presented in table 1.

21
22 15 This study presents a secondary analysis of data collected during a multi-site cross-sectional survey in
23 16 2016 in two Vietnamese provinces: Huế, where CBR is fully implemented and all districts have CBR
24 17 coverage through government implementation and through non-governmental organizations' (NGO)
25 18 activities; and Hòa Bình, where CBR is not implemented by either government or NGOs. The Huế CBR
26 19 program began in 2009 in cooperation with the Huế Rehabilitation Hospital. The program focused
27 20 mainly on activities to increase capacity building for CBR workers, not only in terms of rehabilitation
28 21 skills, but also working to improve their counselling and networking skills. The other focus of the
29 22 program was to strengthen referral pathways for people with disabilities so that they could be
30 23 connected with other existing services in the province, such as schools with teachers who were trained
31 24 to support students with disabilities and vocational training centers. An Android mobile phone
32 25 application (app), available from WHO for the CBR Indicators, was used to collect data during
33 26 interviews (app free to download at:

34 27 <http://play.google.com/store/apps/details?id=com.universaltools.whocbrsurvey&hl=en>).
35 28

36 29 People with disabilities were identified prior to the survey by government records. In both provinces a
37 30 team of five local health care workers were trained by the lead researcher (CM) over two days on how
38 31 to conduct interviews using the survey questions and the app. Data collection was supervised by CM.
39 32 Data were collected during face-to-face interviews with data recorded anonymously. All respondents
40 33 were informed of the purpose of the study, and then provided verbal (Huế) or written consent (Hòa
41 34 Bình). In Huế the decision to provide verbal rather than written consent was justified since requiring
42 35 written consent would embarrass illiterate participants, leading to a decreased willingness to answer
43 36 further questions truthfully. In instances when the respondent had cognitive limitations that prevented
44 37 them from being interviewed, or if the respondent was a minor, a proxy interview with a family
45 38 member was performed. Ethical approval was obtained through the Ludwig-Maximilians-Universität
46 39 Munich Ethics Commission and by the local provincial Ministries of Health.

47 40 **Variables**

48 41 *Outcome Variable*

49 42 To measure community inclusion, a sum score was created from the social base and supplementary
50 43 questions, with the addition of the base question from empowerment. These questions all used the

1 same response scale of 1(*Not at all*) to 5(*Completely*) with the final sum score ranging from 4 to 33,
2 with higher scores indicating higher levels of inclusion (table 1).

3
4 **Table 1.** WHO CBR Indicators and questions used to measure them. Base indicators are shown in
5 bold. The response option for all questions ranged from 1 (Not at all) to 5 (Completely).

Component	Indicator	Survey Question
Social	% of people with disability that feel valued as individuals by members of their community	Do you feel that other people respect you? For example, do you feel that others value you as a person and listen to what you have to say?
	% of people with disability who make their own decisions about the personal assistance they need	Do you get to make decisions about the personal assistance that you need (who assists you, what type of assistance, when to get assistance)?
	% of people with disability make their own decisions about their personal relationships	Do you get to make your own decisions about your personal relationships, such as friends and family?
	% of people with disability who participate in artistic, cultural or religious activities	Do you get to participate in artistic, cultural or religious activities?
	% of people with disability who participate in mainstream recreational, leisure and sports activities	Do you get to participate in community recreational, leisure and sports activities?
	% of people with disability who know their legal rights	To what extent do you know your legal rights?
Empowerment	% of people with disability who make informed choices and decisions	Do you get to make the big decisions in your life? For example, deciding who to live with, where to live, or how to spend your money?

6 *Matching Variables*

7 Matching variables were those available from the WHO CBR Indicators, and were selected based on
8 their theoretical association with community inclusion and CBR group assignment, primarily using CBR
9 Guidelines[2]. Data on *age* and *gender* were collected. Age was collected in categories (see table 2)
10 which were dichotomized for the analysis[20]. Though data on disability severity were not available,
11 *general health status* was used as a proxy, using the question “*How would you rate your health*
12 *today?*”[21]. A variable for *socio-economic status* (SES) was created using a sum score based on the
13 questions “*What is the highest level of education you have achieved or are working to achieve?*” and
14 “*Do you have enough money to meet your needs?*”. The first question is commonly used in SES variable
15 creation, and the second question targets wealth[22,23]. The variable *province of residence*
16 corresponded to CBR coverage (no coverage in Hòa Bình, full CBR coverage in Huế). To account for
17 economic differences between the provinces that might not be captured by SES, the covariate
18 *receiving social protection* (such as for loss of income through old age, sickness or disability) was
19 included. Covariates of *financial awareness* (knowing how to get financial services or social protection
20 if needed), *having access to health services when needed*, and *having access to rehabilitation services*
21 *when needed* were also included. A proxy for autonomy was captured through the covariates of *being*
22 *involved in decision making regarding medical treatment* and *participating in a self-help group if*
23 *desired* (see supplementary table). Seeing as the CBR program in Huế focused on increasing referral
24 pathways within the medical and education sectors, the questions derived from the education
25 component and many from the medical component were not included as matching variables, since
26 including covariates associated with CBR participation but not with community inclusion decrease
27 model precision[24].

28 *Missing Data*

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3 1 Missing data were low (2.25%). Multiple imputation (five imputations) using fully conditional
4 2 specification (MICE package [25] in R Studio Version 0.99.903) was used to replace missing data.
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7 4 **Analysis**

9 5 *Matching on the Propensity Score*

10 6 The number of treated and untreated participants were similar (difference of n=4). Therefore,
11 7 participants were matched using one-to-one nearest neighbour technique, which matched each
12 8 treated unit to one control that was closest using calipers of width equal to 0.25 of the standard
13 9 deviation (SD) of the logit of the estimated propensity score without iteration[26]. This implies that for
14 10 a given treated participant, all the untreated participants are identified whose scores are within this
15 11 specified distance and then the best match is formed. If no match falls within this distance the
16 12 participant is excluded. Participants were matched on ten covariates (see *Matching Variables*).
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21 14 *Balance Diagnostics*

22 15 Baseline comparisons between the covariates were conducted for the matched and unmatched
23 16 samples. Balance diagnosis was performed using the standardized difference method, which compares
24 17 the difference in means of each covariate in units of the pooled SD for the matched and unmatched
25 18 samples[12]. Successful matching is indicated when the absolute standardized differences of means is
26 19 less than 0.25[27].
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30 21 *Comparing Groups*

31 22 For the community inclusion outcome, data matched on the ten covariates were compared using a
32 23 paired t-test[28]. Bootstrapping was performed (1000 samples) in order to produce 95% confidence
33 24 intervals (CI), which has been shown to account for uncertainty in the matching procedure[20].
34 25 A sensitivity analysis was performed using the Rosenbaum Bounds for Hodges-Lehmann Point Estimate
35 26 to assess how robust the findings were to hidden bias due to unobserved covariates ('rbounds' package
36 27 [29] in R Studio Version 0.99.903). The maximum Gamma (the odds of differential assignment to
37 28 treatment due to unobserved factors) was set to 2 with increments of 0.1 to test at which point the
38 29 between group differences are no longer robust[29].
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42 30 Data cleaning was performed using SPSS version 23 (copyright IBM Corporation). PSM was performed
43 31 in R Studio (Version 0.99.903) using the 'MatchIt' package[30].
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46 33 **Patient and Public Involvement**

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48 34 Participants were not directly involved in the development of the research question, study design,
49 35 recruitment or conduct of the study. However, in the province of Huế (where CBR is implemented)
50 36 participants are continually involved in the development of the CBR program, as CBR is participatory
51 37 in nature. It was through their motivation – stemming from the need to prove to the national
52 38 government and international donors that their intervention has an impact in order to receive funds –
53 39 that the survey was conducted in the first place. A study report was submitted to the Huế and Hòa
54 40 Bình Ministries of Health which presented simple numeric and graphic descriptive findings which were
55 41 to be communicated to participants.
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60 43 **RESULTS**

1 Data were available from 298 participants. In Huế, 575 people with disabilities were identified by
 2 government records and 147 were included, while in Hòa Bình 375 people were identified by
 3 government records and 151 were included (sample size calculated using an alpha significance level of
 4 0.05 and power of 90%). Included participants were randomly selected from the complete list. After
 5 the random selection, each interviewer was assigned a group of selected participants based on their
 6 geographic location. Of the randomly selected participants, one in Hòa Bình could not be contacted so
 7 another participant was selected. In both provinces none of the invited participants refused
 8 participation. Males comprised 153(51.3%) of the participants, with a modal age group of 45-64(28.9%)
 9 (see table 2 for further descriptives).

10 In the unmatched sample, CBR participants had higher health status, were more likely to participate in
 11 a self-help group, more financially aware and more likely to be receiving social protection while they
 12 had worse access to rehabilitation services. Some age differences were also noted (table 2). In the
 13 unmatched sample the absolute standardized difference across the 10 covariates ranged from 0.008
 14 to 1.008 indicating bias.

15 When CBR participants were matched with non-CBR participants on the logit of the specified
 16 propensity score model, 74 matched pairs were formed. This meant that 49.7% of CBR participants
 17 were successfully matched to a control. PSM was successful in reducing bias between the covariates
 18 in the matched sample, as the standardized differences ranged from 0 to 0.147 with all values falling
 19 below the threshold value of 0.25[27] (table 2).

20 **Table 2.** Baseline characteristics of CBR participants and non-CBR participants in the unmatched and
 21 matched samples. Absolute standardized differences of means are shown, with differences
 22 exceeding the threshold of 0.25 indicated in bold.

Variable	Unmatched Sample			Matched Sample		
	No CBR (n=151)	With CBR (n=147)	Std. dif. of means	No CBR (n=74)	With CBR (n=74)	Std. dif. of means
Age						
0-5	11 (7.2%)	6 (4.1%)	0.161	3 (4.1%)	5 (6.8%)	0.136
6-12	19 (12.6%)	11 (7.5%)	0.193	7 (9.5%)	5 (6.8%)	0.102
13-17	4 (2.6%)	6 (4.1%)	0.072	2 (2.7%)	1 (1.4%)	0.068
18-24	12 (7.9%)	12 (8.2%)	0.008	7 (9.5%)	7 (9.5%)	0.000
25-44	49 (32.5%)	32 (21.8%)	0.258	23 (31.1%)	22 (29.7%)	0.033
45-64	42 (27.8%)	44 (29.9%)	0.046	21 (28.4%)	26 (35.1%)	0.147
65+	14 (9.3%)	36 (24.5%)	0.353	11 (14.9%)	8 (10.8%)	0.094
Gender (male)	80 (53.0%)	73 (50.0%)	0.066	37 (50.0%)	42 (56.8%)	0.135
SES (range 1-10)	3.74±1.32	3.91±1.30	0.235	3.65±1.45	3.67±1.42	0.020
Health status (range 1-5)	2.89±0.77	3.37±0.70	0.683	3.05±0.75	3.14±0.65	0.115
Receiving social protection	74 (49.0%)	117 (79.6%)	1.008	48 (64.9%)	52 (70.3%)	0.141
Access to health services	132 (87.4%)	126 (85.7%)	0.048	66 (89.2%)	66 (89.2%)	0.000
Access to rehabilitation services	128 (84.8%)	123 (83.7%)	0.263	29 (39.2%)	31 (41.9%)	0.054
Self-help group	63 (41.7%)	75 (51.0%)	0.396	31 (41.9%)	32 (43.2%)	0.027
Financial awareness	73 (48.3%)	122 (83.0%)	0.789	51 (68.9%)	55 (74.3%)	0.134
Involved in treatment decisions	47 (31.1%)	65 (44.2%)	0.137	65 (87.8%)	65 (87.8%)	0.000

Note: continuous variables are presented as means ± standard deviation; dichotomous variables are presented as n(%)

23 To test whether PSM affected the pre-defined outcome of community inclusion, the difference
 24 between groups in the matched and unmatched samples were assessed: similar significant differences
 25 were found. In the matched sample, CBR participants had worse community inclusion scores

(mean=17.86, SD=6.30, 95%CI 16.45-19.32) than non-CBR participants (mean=20.93, SD=6.16, 95%CI 19.50-22.35); $t(73)=3.068$, $p=0.001$. The sensitivity analysis corroborated the results, showing that CBR participants had a median difference in community inclusion score 3.5 points lower than non-CBR participants (Gamma=0). When the Gamma value was increased to 2, the upper and lower bounds did not include zero indicating robust results[29]. In a further sensitivity analysis, to ensure that the covariate of "access to rehabilitation" did not bias the model by being more strongly associated with receiving CBR rather than with the outcome of community inclusion, the model was run excluding this variable. The new model resulted in 75 matched pairs with all standardized differences falling below the threshold. The results of the t-test did not differ from the model including access to rehabilitation; CBR participants had worse community inclusion scores (mean=18.11, SD=5.981, 95%CI 16.72-19.47) than non-CBR participants (mean=21.17, SD=6.381, 95%CI 19.67-22.60); $t(74)=3.310$, $p=0.0014$.

Overall, the results did not differ from the results before PSM: community inclusion for participants with CBR (mean=18.61, SD=5.38) and without CBR (mean=20.64, SD=6.49); $t(296)=2.935$, $p=0.004$ using an independent t-test.

DISCUSSION

To our knowledge, this study presents the first use of PSM as a method for analyzing cross-sectional data in the field of CBR. The study analyzed data collected using the WHO CBR Indicators, and found that community inclusion scores of CBR participants were significantly lower than those of non-CBR participants after PSM. Despite bias being detected in the distribution of covariates between groups in the unmatched sample, the results before PSM did not significantly differ from those after. We conclude that PSM can be successfully applied to cross-sectional CBR data, though in this case the bias reduction provided by PSM did not affect the tested outcome.

PSM has been applied only to longitudinal CBR data so far, but PSM studies using cross-sectional data are available from other fields. These studies had similar results in terms of the methodological success of PSM, but unlike our study they had final outcomes in line with their hypotheses. One such example is the study from Jalan and Ravallion which examines the effect of an employment-based poverty reduction program on income gain, accounting for pre-intervention and foregone income[19]. Through the trial of three PSM methods, they were able to reduce the differences between the two populations and to demonstrate the effectiveness of the program. Another such example is the study from Becerril and Abdulai showing the positive impact of new maize farming technologies on per capita poverty outcomes[18]. Similarly to our study, they detected bias in the distribution of covariates between groups in the unmatched sample, indicating that accounting for bias through PSM was important. In the field of CBR, PSM has been used to evaluate longitudinal CBR data in India, looking at livelihood and health outcomes[31,32]. PSM was used to reduce the bias between the CBR and non-CBR groups, with results showing that CBR participants had better health and livelihood outcomes, and that these differences generally increased over time at both four years and seven years. In our study, data was collected seven years after the program began, which would make the timing comparable and it is therefore plausible that the effect of CBR in our study could already be quantifiable. As in our study, these studies all showed bias between unmatched groups which were reduced in the matched sample after PSM. However, none of these studies presented their outcome results of the unmatched sample for comparison, so it cannot be determined if their final results were unaffected by matching as is the case in our study.

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3 1 The results of the present study go against the anecdotal evidence that CBR has a positive influence
4 2 on the lives of people with disabilities[6,7,33]. Results from longitudinal data indicate that CBR has a
5 3 positive impact on receiving pensions, accessing paid jobs, accessing assistive devices, and personal-
6 4 practical autonomy, with the impact increasing over time[31]. An explanation for our results could be
7 5 that cross-sectional data allow for comparisons between groups at a single time-point, and even after
8 6 PSM is applied to reduce bias the causal relationship between CBR implementation and social inclusion
9 7 cannot be determined. While the cross-sectional data collected in this study represent the first
10 8 quantitative data from the region and therefore an important foundation for future work, the results
11 9 emphasizes the general need for further collection and publication of CBR data, especially longitudinal
12 10 data. Additionally, this study focused on community inclusion - the ultimate goal of CBR - but when
13 11 interpreting results it is also important to consider the specific targets of the program being examined.
14 12 Though CBR aims to impact all aspects of the lives of people with disabilities to increase community
15 13 inclusion, the program in Hué does not directly target community inclusion. The program focuses on
16 14 increasing the capacity of CBR workers and on strengthening referral pathways with the medical and
17 15 educational sectors. Through these activities the community inclusion of people with disabilities
18 16 should improve over time, but since community inclusion was not the direct target of the program, the
19 17 community inclusion effects might only appear after a longer period, which could be a reason for the
20 18 counter-intuitive results. Therefore, when assessing a program in its early stages, it may be more
21 19 important to match the indicators used with the specific targets of programs.

22 20 To our knowledge, this study is the first to implement the recently developed WHO CRB Indicators[4].
23 21 The study highlights how important it is to collect standardized data in the field of CBR in order to
24 22 facilitate comparisons between groups and determine effectiveness of programs. One of the main
25 23 advantages of the CBR Indicators and their data collection strategy is that they are easy to use in the
26 24 field. The indicators allow for descriptive comparisons to be made easily, but for indicators to be used
27 25 appropriately it is important to go beyond these descriptive results using inferential statistics.
28 26 Furthermore, no single indicator or even a set of indicators is capable of capturing all changes in
29 27 dynamic settings. The use of indicators alone has the potential limitation of collecting meaningless or
30 28 misleading information,[34] and therefore they should be used as part of a broad evaluation strategy,
31 29 in combination with qualitative and participatory evaluations[33]. Another way to reduce the
32 30 limitations arising from indicator use is to continually test and re-assess the indicators[34]. In the case
33 31 of the CBR Indicators, a priority should be to do this in partnership with communities and people with
34 32 disabilities in order to promote their uptake.

35 33 The use of PSM as a method for analysis of cross-sectional data collected from the CBR Indicators is
36 34 conceptually strong, due to its ability to reduce bias due to confounding variables in observational
37 35 studies[9]. However, the methodological limitations of PSM also need to be considered. PSM requires
38 36 that each participant has a non-zero probability of receiving treatment, meaning only people with
39 37 disabilities can be included in the analysis. Due to this, one of the main advantages of the CBR
40 38 Indicators, namely the ability to use comparison individuals from the community, is lost[4].
41 39 Furthermore, PSM only controls for known covariates which means that there is a potential for bias if
42 40 some covariates that affect the outcome are not included[9]. For example, in this study no data were
43 41 available on the ethnicity of participants, despite its known association with social disparities in
44 42 Vietnam[35]. Another such covariate in this study could be disability severity, although this was
45 43 partially adjusted for in both the participant selection, whereby all people with disabilities were
46 44 identified using the same government disability criteria, and further in the analysis through the

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3 1 inclusion of the self-rated health covariate. Another limitation of PSM is that it leads to reduced sample
4 2 size which could limit generalizability, though this is partly addressed through the provided sensitivity
5 3 analysis. The reduced sample size also increases the risk of type II error[36], but the sample size of this
6 4 study met the commonly recommended minimum sample size of $10(p + 1)$, where p is the number of
7 5 matching variables[37]. This study presents a starting point to encourage the generation of
8 6 quantitative CBR research and demonstrates one possible method for reducing bias when analyzing
9 7 cross-sectional CBR data. Further studies should look into additional statistical methods for analyzing
10 8 the results obtained from the CBR Indicators.

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14 9 Based on the present study, we recommend the further use and testing of the WHO CBR Indicators to
15 10 increase standardized data collection in the field of CBR. In accompaniment to increased data
16 11 collection, we recommend PSM as a method to reduce bias in cross-sectional CBR data analyses,
17 12 especially for international comparisons where differences between populations may be greater than
18 13 the within country differences observed in this study. Since using cross-sectional data presents
19 14 limitations even after adjusting for bias, we also emphasize the need for future longitudinal data
20 15 collection in order to assess effectiveness in the field of CBR.

21 16 **CONCLUSION**

22 17 This study presents the first use of PSM as a method for analyzing cross-sectional CBR data. While
23 18 randomized and longitudinal data are ideal for evaluations, cross-sectional data presents the
24 19 advantage of being more feasible to collect and thereby providing an essential foundation to generate
25 20 hypotheses and perform further studies. Therefore, it is essential that appropriate statistical methods
26 21 are applied to capitalize on available data. The potential of using PSM for analyzing cross-sectional CBR
27 22 data was demonstrated, though further research should investigate alternative inferential methods,
28 23 such as cluster matching or adjusted regression, which may be more suitable in allowing for the
29 24 comparison of the differences between persons with and without disabilities in line with the WHO CBR
30 25 Indicators. We recommend that the questions and indicators be continually reviewed, and that future
31 26 cross-sectional CBR studies use PSM to reduce bias when comparing groups.

32 27 33 28 **FUNDING**

34 29 This research received no specific grant from any funding agency in the public, commercial or not-for-
35 30 profit sectors.

36 31 **COMPETING INTERESTS**

37 32 The authors declare no competing interests.

38 33 **DATA SHARING**

39 34 The data are owned by the World Health Organization (WHO). Data are available from the WHO for
40 35 researchers who meet the criteria for access to confidential data. Interested researchers can access
41 36 the data by the same means the authors accessed them, by contacting WHO under
42 37 disability@who.int. Statistical code is available from the corresponding author.

43 38 **ACKNOWLEDGEMENTS**

1 The authors express gratitude to those from the Vietnamese Ministries and the local healthcare
2 workers who lent their knowledge and field experience. Special thanks go out to the interviewers who
3 took the time to visit and speak with the participants; in Huế: Nguyen Thi Phung Diem, Nguyen Van
4 Hong, Thuong Thi Huong Giang, Thian Cong Chirh, and Nguyen Thi Ngoc Anh and in Hoa Binh: Ha Thi
5 Thoan, Vu Dury Hieu, Le Tleaal Hoa, Nguyen Quoc Dung, Le Vai Huy, and Nguyen Thanh.

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9 Methodology: CM JW CS
10 Data curation: CM DMT
11 Formal analysis: CM
12 Project administration: CM JW CS
13 Resources: CM JW CS DMT
14 Supervision: CM DMT CS JW
15 Writing – original draft: CM CS JW
16 Writing – review & editing: CM JW CS DMT

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Supplementary Table. The WHO CBR Survey questions, response options and analysis categories for the matching variables.

Variable	Survey Question and Response Options	Analysis Categories
Gender	Record the gender of the selected participant	Male=1, Female=0
Age	How old are you?	0-5yrs=1; 6-12yrs=2; 13-17yrs=3; 18-24yrs=4; 25-44yrs=5; 45-64yrs=6; 65+yrs=7
Education Level (for creation of SES)	What is the highest level of education you have achieved, or are working to achieve? <i>1=No schooling or never completed any grade; 2=Elementary education; 3=Vocational education; 4=Professional training; 5=Secondary school; 6=College; 7=University; 8=Post-graduate studies; 9=Other</i>	If respondent answered 1: score=0 If respondent answered 2: score=1 If respondent answered 3,4,5: score=2* If respondent answered 6,7,8: score=3
Employment Grade	What is your current working situation? <i>1=Not working and looking for work; 2=Not working for wages and not looking for paid work; 3=Working for wages or salary with an employer; 4=Working for wages, but currently on sick leave; 5=Self-employed or own-account worker; 6=Working as unpaid family member; 7=Retired because of the health condition; 8=Retired because of age; 9=Early retirement; 10=Other</i>	If respondent answered 1: score=0 If respondent answered 6: score=1 If respondent answered 2,3,4,5,7,8,9: score=2 If respondent answered 10: score=missing
Health Status (for creation of SES)	In general, how would you rate your health today? <i>1 = Very good; 2 = Good; 3 = Neither poor nor good; 4 = Poor; 5 = Very poor</i>	Inverted
Received needed medical care	In the last 12 months, has there been a time when you needed health care but did not get that care? <i>1 = Yes; 2 = No; 3 = No need for health care in the past 12 months</i>	If respondent answered 1: score=0 If respondent answered 2 or 3: score=1
Involved in making treatment decisions	On your last visit to a health care provider, to what extent were you involved in making decisions for your treatment? <i>1 (Not at all); 2; 3; 4; 5 (Completely)</i>	No transformation
Received needed rehabilitation services	In the last 12 months, has there been a time when you needed rehabilitation services, such as physical, occupational, or speech therapy, but did not get those services? <i>1 = Yes; 2 = No; 3 = No need for rehabilitation services in the past 12 months</i>	If respondent answered 1: score=0 If respondent answered 2 or 3: score=1
Aware of financial services	Do you know how to get financial services such as credit, insurance, grants, and savings programs? <i>1 = Yes; 2 = No</i>	If respondent answered 1: score=1 If respondent answered 2: score=0
Receive social protection	Do you currently benefit from any social protection program, such as loss of income through old age, sickness or disability? <i>1 = Yes; 2 = No</i>	If respondent answered 1: score=1 If respondent answered 2: score=0
Participation in self-help group	Are you a member of a self-help group? <i>1=Yes; 2=No, but I would like to; 3=No, I don't want to</i>	If respondent answered 1 or 3: score=1 If respondent answered 2: score=0

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract Pg 1, 1-3 (b) Provide in the abstract an informative and balanced summary of what was done and what was found Pg 2, 3-28
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported Pg 4, 2-39
Objectives	3	State specific objectives, including any prespecified hypotheses Pg 4, 40- pg 5, 3
Methods		
Study design	4	Present key elements of study design early in the paper Pg 5, 7-8; 14
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection Pg 5, 14-37
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants Pg 5, 27; pg 8, 5 (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable Pg 5, 40- pg 6, 23; Supplementary Table
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group Pg 5, 7-13
Bias	9	Describe any efforts to address potential sources of bias Pg 7, 20-27 → The analysis uses PSM, a method to reduce bias
Study size	10	Explain how the study size was arrived at Pg 8, 2-5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why Pg 5, 40- pg 6, 23; Supplementary Table
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding

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Pg 6, 6-29

(b) Describe any methods used to examine subgroups and interactions

(c) Explain how missing data were addressed

Pg 7, 1-2

(d) *Cohort study*—If applicable, explain how loss to follow-up was addressed

Case-control study—If applicable, explain how matching of cases and controls was addressed

Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy

(e) Describe any sensitivity analyses

Pg 7, 23-27; pg 9, 8-14

Continued on next page

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Results

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed Pg 8, 2-4
		(b) Give reasons for non-participation at each stage Pg 8, 7-8
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders Pg 8, 9-10, 21-25
		(b) Indicate number of participants with missing data for each variable of interest Pg 7, 1-2
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures Pg 5, 40- pg 6, 2
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included Pg 9, 1-5
		(b) Report category boundaries when continuous variables were categorized
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses Pg 9, 5-14

Discussion

Key results	18	Summarise key results with reference to study objectives Pg 9, 20-26
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias Pg 10, 7-22; 29-33; pg 10, 38- pg 11, 1-7
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence Pg 11, 8-18
Generalisability	21	Discuss the generalisability (external validity) of the study results Pg 11, 4-6

Other information

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based Pg 11, 32-33
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2 *Give information separately for cases and controls in case-control studies and, if applicable, for exposed and
3 unexposed groups in cohort and cross-sectional studies.
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5 **Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and
6 published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely
7 available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at
8 <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is
9 available at www.strobe-statement.org.
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