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Research Article

Translation and validation of the Chinese self-report version of Spinal Cord Independence Measure (SCIM-SR): Rasch psychometric analysis and online application

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ABSTRACT

Spinal Cord Independence Measure (SCIM) was an important functional outcome measure specifically designed for spinal cord injury (SCI) patients, with the self-reported version of SCIM (SCIM-SR) published in 2013. This study aims to translate the SCIM-SR into Chinese, and to investigate the validity of Chinese SCIM-SR among SCI patients. This Chinese version of SCIM-SR was translated into Chinese in a standardized approach, and then filled out by a sample of patients with SCI (n = 205) within 3 days after admission. Validity of Chinese SCIM-SR was then analyzed using Rasch analysis and principal component analysis. The subscale Selfcare and subscale Mobility showed good fit to the Rasch model, with no significance found in Chi-square test results for item-trait interaction, using Bonferroni adjustment for the significant level (χ^2 =18.125, P = 0.111; χ^2 =33.629, P = 0.006). Mean fit residual for items and persons of each subscale were within ± 2.5. The model fit of the subscale of Respiration and Sphincter Management was not satisfactory even after deleting one item and merging two items with local dependence. However, Kaiser-Meyer-Olkin test was > 0.50 in total score and all the subscales of Chinese SCIM-SR, and P < 0.05 in the Bartlett's test. There was no differential item functioning for gender, time post injury, age, and etiology in any of the three subscales. An online version of Chinese SCIM-SR was also developed. It is concluded that the SCIM-SR in Chinese is valid for application in individuals with SCI. SCIM-SR is considered as an important tool for self-reporting functional status from SCI individuals' perspective.

1. Introduction

Functional status after spinal cord injury (SCI) is an important endpoint as it provides information related to the ability and performance in activities of daily routine [1,2]. Thus, the assessment of functional capacity is of high relevance in individuals with SCI. As an outcome measure of functioning specifically designed for spinal cord injury (SCI) patients, the Spinal Cord Independence Measure (SCIM) has been developed [3] and updated for several times [4]. The 3rd and 4th versions, SCIM III & IV, have been proved to be valid and reliable for traumatic/non-traumatic SCI in both adults and youth [5–12]. Based on these evidences, SCIM has been implemented worldwide as the essential functional recovery outcome measure for SCI [13,14].

SCIM is usually administrated by observation or interview by healthcare professionals, [15,16]. In addition, an additional version of SCIM III based on patient-self-report (SCIM-SR) was developed [17]. It is proposed that assessment tools regarding functional status would bring more benefits to the patients when performed by self-report, as the self-reported outcome is more efficient in recording the actual experience of patients in their daily lives without the bias from the professional raters [18]. Furthermore, the follow-up of in the chronic stage of SCI usually relies even more on self-administrated assessment given the

Abbreviations: DIF, differential item functioning; GRRAS, guidelines for reporting reliability and agreement studies; KMO, Kaiser-Meyer-Olkin test; LID, local item dependence; PSI, person separation index; RS, Respiration and Sphincter Management; SCI, spinal cord injury; SCIM, Spinal Cord Independence Measure; SCIM-SR, self-report version of SCIM III.

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more convenient data collection [17,19].

Based on these advantages, SCIM-SR has been considered as an important alternative tool to evaluate the performance of daily task in SCI patients [17]. The good validity of the original English version [17] as well as several translations including Spanish [20], Greek [21] and Italian [22] facilitated the wide use of SCIM-SR in different countries and regions around the world. A Chinese version of SCIM-SR was also published in 2021 [23]. The authors demonstrated good reliability and validity of the Chinese version, using conventional statistical methods.

In this study, we further evaluated the validity of the Chinese SCIM-SR using Rasch analysis. We also investigated if the validity of Chinese SCIM-SR was influenced by factors such as time post injury, etiology, gender, and age of patients.

2. Methods

2.1. Translation of Chinese SCIM-SR

The SCIM-SR was translated into Chinese in a forward-backward translation approach [24]. Two independent translations were performed by two physicians who were familiar with SCIM-SR bilingually. Afterwards the two translations were scrutinized by an expert in SCI rehabilitation. Then a combined version of translation was drafted for back translation by a linguistic expert who has experience of clinical research but did not have insight to the content of the scale. The original English and the back-translated texts were further checked and reviewed by 2 senior specialists in SCI rehabilitation. After necessary revision and checking, the Chinese SCIM-SR was finally created (in Supplemental materials).

2.2. Participants

Between April 2017 and July 2019, the SCI individuals admitted to our inpatient rehabilitation facility were included in this study. Eligible participants needed to be native Chinese speakers aged over 18 years. Patients with functional disability caused by other disorders or impaired cognitive function were excluded. According to the recommendation of the guideline, a sample size of at least 80 participants was acceptable for the validity investigation [25]. Assuming the rate of invalid data was 10 %, at least 89 patients should be included. The protocol of this study was approved by the local clinical research ethics board (M2017132).

2.3. Procedures

Each participant filled in a Chinese SCIM-SR form during the first 3 days after admission. For those patients whose hand function was poor, a physician helped them with filling in the SCIM-SR but gave no explanation to the items.

2.4. Data analyses

The Rasch model suggested that response to each item in a scale reveals the linear probabilistic interaction of a user's "ability" and a question's "difficulty". The Rasch model provides fit statistics to indicate the accuracy of the different items to describe the participants' performance and the relevance of individual participants to fit the group.

Rasch analysis was conducted using the RUMM2030 software (RUMM Laboratory, Perth, Australia). Bonferroni method was used for the adjustment of significance level when Rasch analysis was performed for multiple rounds.

To investigate overall fit to the Rasch model, item-trait interaction analysis was performed for each subscale of the Chinese SCIM-SR. A non-significant P value in Chi-square test, and mean fit residual for items and persons within $\pm$ 2.5 (SD $<$ 1.5) indicates good overall fit.

If the result of overall fit was unsatisfactory for a given subscale, single-item fit analysis was further performed for each item within it. Local item dependence (LID) is evaluated by correlations between the Rasch residuals of two items. Residual correlations $>$ 0.3 above average indicated item dependence [26].

Person separation index (PSI) was calculated for each subscale to reveal the internal consistency and separability of functional ability, with PSI $>$ 0.7 interpreted as good. Differential item functioning (DIF) was analyzed for each subscale to investigate if the function of the tool was influenced by personal factors (gender, age, etiology, and time post injury). A non-significant P value of DIF analysis indicates stable validity independent from these factors.

For total score and each subscale of the Chinese SCIM-SR, ceiling and floor effect was evaluated. Principal component analysis was performed to investigate the convergent validity. using Bartlett's test and Kaiser-Meyer-Olkin (KMO) test in SPSS 22.0 (IBM, New York, USA). The level of significance was set at P $<$ 0.05. The KMO measure $>$ 0.50 was considered as acceptable [21].

2.5. Development of the online version of Chinese SCIM-SR

An online version of Chinese SCIM-SR was developed based on a website for surveys and exams which is well-known in China (www.wjx.cn). A weblink and a Quick Response code can be generated automatically for the scale. Answers submitted by the users can be download and analyzed at the researchers' side.

3. Results

The general characteristics are presented in Table 1. A total of 205 participants (137 men and 68 women) were included in this study.

3.1. Rasch analysis

After the extreme scores were excluded, the sample size of Rasch analysis were 161, 195 and 104 participants for subscale Self-care, subscale Respiration and Sphincter Management (RS), and subscale Mobility, separately.

The results of overall fit analysis (item-trait interaction analysis) for the three subscales were listed in Table 2. The subscale Self-care showed

Table 1
Participants' general characteristics.

	Total (n = 205)
Age in years, Median (IQR)	49 (35-62)
18-29 years, n (%)	28 (13.7)
30-59 years, n (%)	120 (58.5)
> 60 years, n (%)	57 (27.8)
Gender	
Male, n (%)	137 (66.8)
Female, n (%)	68 (33.2)
Etiology	
Sports and leisure, n (%)	5 (2.4)
Assaults, n (%)	6 (2.9)
Traffic accidents, n (%)	51 (24.9)
Falls, n (%)	79 (38.5)
Other traumatic, n (%)	9 (4.4)
Non-traumatic, n (%)	55 (26.8)
Level of injury	
Tetraplegia, n (%)	115 (56.1)
Paraplegia, n (%)	90 (43.9)
AIS grade	
A, n (%)	45 (22.0)
B, n (%)	41 (20.0)
C, n (%)	32 (15.6)
D, n (%)	87 (42.4)
Time since injury (month), Median (IQR)	2 (1-4.5)
Acute (< 1 month), n (%)	91 (44.4)
Post-acute (> = 1 month), n (%)	114 (55.6)

Abbreviation: IQR, interquartile range; AIS, American Spinal Injury Association (ASIA) Impairment Scale.

Table 2
Summary of results of the Rasch analyses.

Analysis and action	Item fit residual, mean (SD)	Person fit residual, mean (SD)	Overall model fit		Person separation index
			Chi-square	P value	
Selfcare (n = 161)					
Original items	-0.245 (0.917)	-0.263 (0.695)	18.125	0.111	0.804
Respiration and sphincter management (n = 195)					
Original items	-0.271 (0.380)	-0.357 (0.400)	25.816	0.001[a]	0.841
Deleted Item 6 (Bladder management)	-0.463 (0.749)	-0.303 (0.292)	20.604	0.002[a]	0.751
Merged Item 6 (Bladder management) and Item 7 (Bowel management)	-0.203 (0.202)	-0.292 (0.336)	16.656	0.011[a]	0.863
Mobility (n = 104)					
Original items	-0.322 (1.902)	-0.323 (0.863)	40.800	0.002	0.877
Deleted Item 9 (Mobility in bed)	-0.185 (0.732)	-0.309 (0.875)	33.629	0.006	0.876

[a] Significant according to the Bonferroni-adjusted P value.

adequate fit to Rasch model in the Chi-square test ($\chi^2 = 18.125$, P = 0.111). For the single-item fit analysis in this subscale, all the fit residuals were also within ± 2.5 (Table 3).

The subscale of RS did not fit the Rasch model well ($\chi^2 = 25.816$, P = 0.001, Bonferroni-adjusted P = 0.05/4 = 0.0125) (Table 2). Single-item fit analysis showed poor fit of Item 6 (Bladder management) in this subscale (Chi-square's P < 0.001) (Table 3). Residual correlation between Item 6 and Item 7 (Bowel management) was 0.395, indicated local item dependence in these items. In order to attain satisfactory fit, multiple rounds of Rasch analysis were conducted, with Item 6 deleted or Item 6/7 merged as a testlet. Unfortunately, the overall fit was still not good enough ($\chi^2 = 20.604$, P = 0.002, Bonferroni-adjusted P = 0.05/3 = 0.0167; $\chi^2 = 16.656$, P = 0.011, Bonferroni-adjusted P = 0.05/3 =0.0167) (Table 2).

Table 3
Summary of single-item fit analysis.

Item	Location	Fit residual	Chi-square	P value
1. Eating and drinking	-1.530	0.652	0.474	0.789
2A. Washing upper body and head	0.680	-0.481	2.009	0.366
2B. Washing lower body	1.497	-0.627	1.334	0.513
3A. Dressing upper body	-0.373	-1.573	7.857	0.020
3B. Dressing lower body	0.724	0.943	2.950	0.229
4. Grooming	-0.997	-0.387	3.500	0.174
5. Breathing	-5.493	-0.832	2.231	0.328
6. Bladder management	1.295	-0.155	12.898	0.002[a]
7. Bowel management	1.949	0.001	4.753	0.093
8. Using the toilet	2.249	-0.097	5.934	0.051
9. Mobility in bed	-1.281	4.452	4.616	0.099
10. Transfers from bed to wheelchair	-1.116	0.479	7.996	0.018
11. Transfers from wheelchair to toilet/tub	-0.659	0.456	5.867	0.053
12. Moving around indoors	-0.741	0.551	4.278	0.117
13. Moving around moderate distances (10–100 m)	-0.145	-0.894	0.571	0.752
14. Moving around outdoors for more than 100 m	0.008	-0.639	5.661	0.059
15. Going up or down stairs	1.405	0.425	1.169	0.557
16. Transfers from wheelchair into car	0.090	-0.631	0.787	0.675
17. Transfers from floor to wheelchair	1.158	-1.221	4.511	0.105

[a] Significant according to the Bonferroni-adjusted P value.

Regarding the subscale Mobility, a significant P value was found for Chi-square test ($\chi^2 = 40.800$, P = 0.002, Bonferroni-adjusted P = 0.05/9 = 0.006) (Table 2) with mean fit residuals within ± 2.5. The SD of fit residual for persons (1.902) was slightly higher than 1.5. Single-item fit analysis showed that fit residual of Item 9 (Mobility in bed) was 4.452 (> 2.5) (Table 3). Thus, a second round of analysis was performed with Item 9 deleted, and the result showed acceptable fit ($\chi^2 = 33.629$, P = 0.006, Bonferroni-adjusted P = 0.05/8 = 0.006).

PSI of each subscale was also listed in Table 2, with all the three subscales above 0.7, indicated good internal consistency of each subscale. No DIF was found in any of the three subscales for gender, age, etiology, and time post injury.

3.2. Principal component analysis

As shown in Table 4, KMO test was > 0.50 for the total score and three subscales of Chinese SCIM-SR, and P < 0.05 in the Bartlett's test. Only one factor was extracted from each subscale (sum of the included item scores) and total score (sum of subscale scores), indicating good convergent validity of the scale.

3.3. Ceiling and floor effects

The ceiling effect was 0 (0 %) for total score of Chinese SCIM-SR, 2 (1.6 %), 7 (5.6 %) and 5 (4.0 %), for the Selfcare, Respiration and sphincter management, and Mobility subscales, respectively. Floor effect was 4 (3.2 %) for total score, 27 (21.4 %), 5 (4.0 %), and 55 (43.7 %), for the subscales respectively.

3.4. Online version of Chinese SCIM-SR

The online version of Chinese SCIM-SR is now available at https://www.wjx.cn/vm/Q0Ibpj3.aspx, and can also be accessed via scanning the Quick Response code (Fig. 1) using a smartphone.

In order to make the flow of the on-line scale clear and convenient, the items that display after Item 6A (Use of an indwelling catheter) are different according to the user's choice for it. If the user chooses "Yes", the next item will be Item 7A, and Items 6B and 6C are hided automatically (Fig. 2A). On the other hand, if the user chooses "No" for Item 6A, then Items 6B and 6C are displayed in the next questions (Fig. 2B).

4. Discussion

In our study, SCIM-SR was translated into Chinese according to a recommended procedure. Afterward the translation was tested for validity using Rasch analysis and principal component analysis among native Chinese individuals with SCI. The ceiling and floor effects were evaluated. The results brought helpful information regarding the good validity of the Chinese SCIM-SR.

Assessment of function status is one of the important aspects for individuals suffering from SCI, and should be performed at initial evaluation after injury as well as during lifelong follow-up [1]. Thus, it is

Table 4
Principal component analysis of the Chinese versions of SCIM-SR (n = 205).

	KMO test	Bartlett's test	Number of factors extracted
Total score	0.82	< 0.01	1
Selfcare	0.83	< 0.01	1
Respiration and sphincter management	0.71	< 0.01	1
Mobility	0.90	< 0.01	1

Abbreviation: SCIM, Spinal Cord Independence Measure; SR, self-report; KMO test, Kaiser-Meyer-Olkin test.

Fig. 1. Quick response code for the online version of Chinese SCIM-SR.

essential to detect changes of the functional capacity [27] or possible effects of clinical care [14,28]. Besides, monitoring the changes in functional status will also provide better understanding of the recovery after SCI [29]. Several outcome measures are now used for assessing the functional capacity after SCI, such as Walking Index for Spinal Cord Injury (WISCI), Functional Independence Measure (FIM), and Quadriplegia Index of Function (QIF) [30]. However, SCIM was the most widely accepted tool specifically designed for the general capacity of functioning in daily life of individuals with SCI [1], which is performed by observation or interview [16]. A team consisting of physicians, physical therapist, occupational therapists and nurses is often used for assessment [15].

With the continuously increasing recognition of the patient-centered approach, it is proposed that the self-administrated assessment tools regarding functional status and quality of life would bring more benefits to the patients and cost fewer resources [31]. Patient-reported outcome measures (PROMs) is used to ask a patient to directly report their individuals' experience without additional interpretation of the response by others, thus reflect the actual situation of themselves [18]. This is necessary for comprehensive evaluation of the influence of diseases and healthcare interventions from the patient perspective. General PROMs as well as disease-specific PROMs for different medical conditions have been developed and used in clinical practice and scientific research [18,32]. Regarding the PROM of functional status after SCI, SCIM-SR was developed in 2013 [17]. The validity of the original English version [17] as well as several translations [20–22] have been investigated, and it has been considered as an important tool for reporting functional status from patients' viewpoint. In this study, Chinese translation of SCIM-SR was conducted using a standardized forward-backward protocol [24], to make sure the optimized preservation of the original meaning of the English version.

Chinese version of SCIM-SR was evaluated using conventional statistical methods (also known as classical test theory, CTT) and demonstrated good reliability and validity of the Chinese version, using conventional statistical methods [23]. Rasch analysis is an analytical method created for developing tests of abilities based on users' responses to questions. The basic idea is to include items that vary sufficiently in difficulty so that the scale score will be sensitive enough to distinguish a wide range of ability levels. As the functioning performance varies so much in SCI individuals, it is necessary to evaluate the validity of SCIM in a new language using Rasch model, as the original versions have already do [6,12].

In this study, Rasch analysis was used to investigate the validity of three subscales in the Chinese SCIM-SR. Good Rasch model fit was found in subscale Selfcare. For subscale Mobility, although the power of overall fit analysis seems influenced by Item 9 (mobility in bed), with SD of fit residual for persons was slightly higher than 1.5, acceptable fit was found with Item 9 excluded. On the other hand, Item 9 itself showed satisfactory fit in the single-item analysis. This might be attributed to the difference of content between Item 9 and other items (focusing on transfer and mobility on the ground) in this subscale. Meanwhile, results of principle component analysis supported the unidimensionality of this

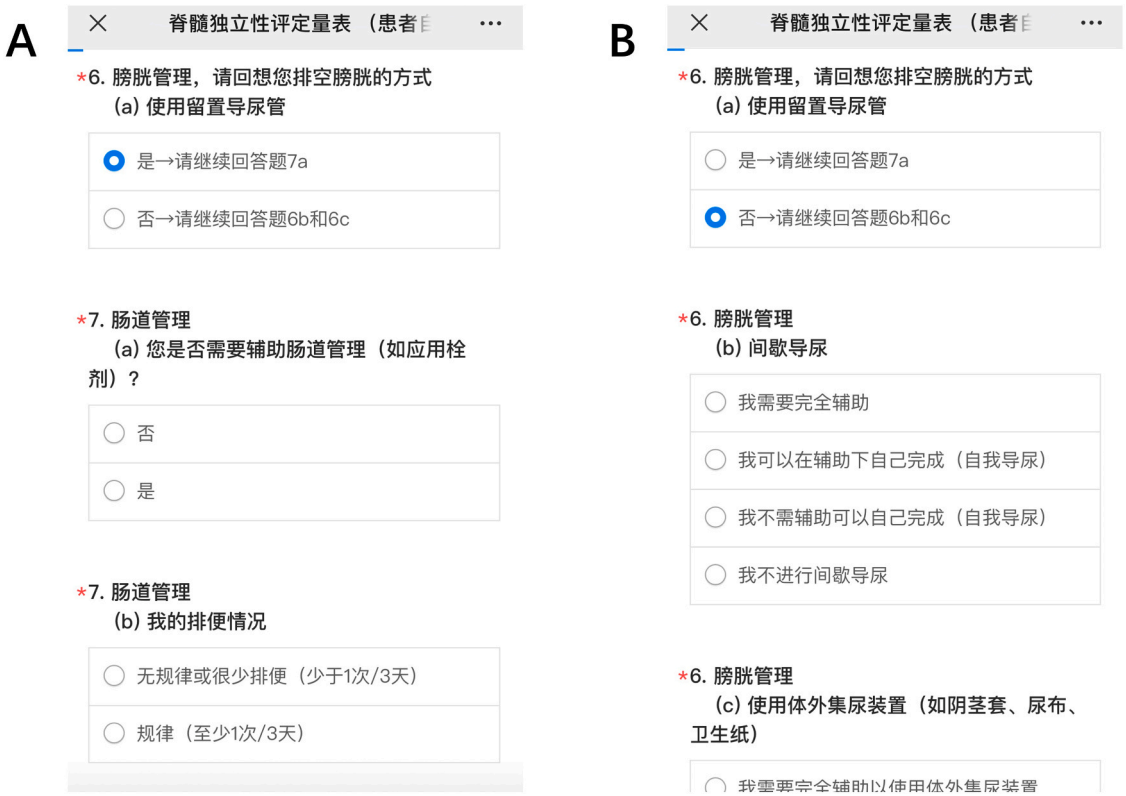

Fig. 2. The items that display after Item 6A (Use of an indwelling catheter) are different according to the user's choice for it. If the user chooses "Yes", the next item will be Item 7A, and Items 6B and 6C are hided automatically (A). On the other hand, if the user chooses "No" for Item 6A, then Items 6B and 6C are displayed in the next questions (B).

subscale. It is indicated that both subscales are valid to evaluate the functional independence in the field of selfcare and mobility for SCI individuals, and identify the different levels of functioning and disability.

However, the overall fit of subscale RS was unsatisfactory. This result was not reversed by deleting the item that do not fit the Rasch model (Item 6) or merged the items that showed high residual correlation (Item 6 and 7) as a testlet. As reported in the published studies of Rasch analysis for original SCIM III and SCIM IV, fit index of the subscale RS was also the lowest among three subscales, which was consistent with the result of this study. For the original SCIM III, the mean item fit index was 0.92, 0.79 and 0.94 for subscale Selfcare, subscale RS, and subscale Mobility, respectively [6]. Meanwhile, reliability index of the original SCIM IV was 0.9, 0.8, 0.9 for subscale Selfcare, subscale RS, and subscale Mobility, separately [12]. One possible reason is that items in this subscale focused on different aspects of functioning such as respiration, bladder management and bowel routine, making it less suitable for Rasch analysis. Thus, principle component analysis was further performed using KMO test and Bartlett's test, and the results revealed good convergent validity of the scale.

Convergent validity of the three subscales and the overall scale are good in the Chinese SCIM-SR, which is similar to the results reported in the study of the Greek version [21], except that the KMO test result of the subscale Respiration and Sphincter Management is slightly higher in our study. This may be attributed to the relatively lower KMO measure of the item Respiration (0.42) in the Greek version [21]. Nevertheless, P value of Bartlett's test was < 0.05 in both the Chinese and the Greek versions.

The results of our study illustrated that the good validity of the Chinese SCIM-SR was not influenced by age, gender, etiology or time since injury, which is similar to previous studies on SCIM-SR, including the original version [6,17,22]. It is proved that the good validity of the Chinese SCIM-SR is stable in the general SCI population.

4.1. Study limitations

There are several limitations in our study. The study was performed in an inpatient setting, few participants obtained obvious functional improvement during the relatively short stay in the hospital, hence the responsiveness of the Chinese SCIM-SR was not assessed. Another limitation is that the outpatient and community-based SCI population were not included in the study. Further research is required for longer follow-up of SCI individuals as well as in different settings.

5. Conclusion

In this study, SCIM-SR was translated into Chinese and tested for its validity using Rasch analysis. It is demonstrated that Chinese SCIM-SR is valid as a self-report functional assessment for SCI individuals. Furthermore, the good validity is not influenced by age, gender, etiology or time since injury. Thus, SCIM-SR could be considered as an important tool for self-reporting functional status from SCI individuals' perspective, especially when face-to-face observation or interview by healthcare professionals is not feasible.

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CRediT authorship contribution statement

Fin Biering-Sørensen: Methodology, Validation, Writing – review & editing. **Guoqing Cui:** Validation, Writing – review & editing. **Kun Li:**

Methodology, Supervision, Validation, Writing – review & editing. **Nan Liu:** Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. **Huayi Xing:** Investigation, Methodology, Writing – original draft, Writing – review & editing.

Conflicts of interests

No conflicts of interest, financial or otherwise, are declared by the author(s).

Data availability

The data generated or analyzed in this study are available from the corresponding author upon reasonable request.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.csbj.2024.03.029.

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