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Research paper

The Chinese Mandarin COMHON Index and Braden Scale to assess pressure injury risk in intensive care: An inter-rater reliability and convergent validity study

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ABSTRACT

Background: The COMHON Index is an intensive-care-specific pressure injury risk assessment tool, which has demonstrated promising psychometric properties. It has been translated into Chinese Mandarin but requires inter-rater reliability testing and comparison to the standard care instrument (Braden Scale) before clinical use.

Objectives: This study aimed to test and compare the inter-rater reliability and convergent validity of the Chinese Mandarin versions of the COMHON Index and Braden Scale.

Methods: The study was conducted in a Chinese comprehensive intensive care unit. Based on a sample size calculation, five registered nurse raters with at least 6-months experience independently conducted risk assessments for 20 adult patients using both the COMHON Index and Braden Scale. Intraclass correlations (ICC) for inter-rater reliability, standard errors of measurement (SEM), and minimally detectable change (MDC) were calculated. Convergent validity was assessed using Pearson Product Moment Correlation for sum scores and Spearman's rho for subscales.

Results: Inter-rater reliability of COMHON Index and Braden Scale sum scores was very high (ICC [1,1] = 0.973; [95% confidence interval 0.949–0.988]; SEM 0.54; MDC 1.50) and high (ICC [1,1] = 0.891; [95% confidence interval 0.793-0.951]; SEM 0.93; MDC 2.57), respectively. All COMHON-Index subscales demonstrated ICC values >0.6, whereas two Braden Scale subscales (*Mobility*, *Activity*) were below this threshold. Instrument sum scores were strongly correlated (Pearson's $r = -0.76$ [$r^2 = 0.58$]; $p < 0.001$), as were three subscale item pairs (mobility $r_s = -0.56$ [$r^2 = 0.32$]; nutrition $r_s = -0.63$ [$r^2 = 0.39$]; level of consciousness/sensory perception $r_s = -0.67$ [$r^2 = 0.45$] $p < 0.001$).

Conclusion: Both the COMHON Index and Braden Scale demonstrated high levels of inter-rater reliability and measured similar constructs. However, the COMHON Index demonstrated superior inter-rater reliability and the results suggest that it better detects changes in patient condition and subsequently pressure injury risk. Further testing is recommended.

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1. Introduction

Pressure injury (PI) may occur as a consequence of hospital admission, resulting in ongoing harm for patients[1] and increased mortality, length of stay, and healthcare costs.[2] Critically ill individuals admitted to an intensive care unit (ICU) are a specialised population that is particularly vulnerable to PI.[3] Internationally, a recent point prevalence study conducted across over 1100 ICUs in 90 countries found an intensive-care-acquired PI prevalence of 16.2%.[4] In China, secondary analyses of these international data indicated ICU-acquired prevalence may be lower at 4.3%.[5] Nonetheless, such levels of prevalence are clinically significant, given that recent research suggests ICU nurses' knowledge and practice of PI prevention[6] and individualised repositioning implementation[7] may be inadequate.

The vulnerability of critically ill individuals to PI is related to factors associated with severe illness and ICU admission, such as impaired mobility, oxygenation and perfusion, vasopressor and mechanical ventilation use, and prolonged stay.[8] Subsequently, those admitted to the ICU have specific additional needs in relation to PI prevention.[9] Prevention of PI should be underpinned by a risk assessment, which guides the selection and implementation of PI preventative interventions.[10] PI risk assessment may be aided by the use of an assessment tool such as the Braden Scale or Waterlow score, both of which are commonly used clinically in the ICU.[11] However, these and other non-ICU-specific tools do not account for the specialised needs and risk factors of critically ill individuals.[12,13]

The COMHON Index is an ICU-specific PI risk assessment tool, which is available in several languages.[14] It assesses five components of PI risk; level of COnsciousness (per the Richmond Agitation–Sedation Scale[15]), Mobility, Haemodynamics, Oxygenation and Nutrition. Developed initially in Spain, it demonstrated good inter-rater reliability (κ 0.89–0.93) during testing in two hospitals.[16] The tool also demonstrated convergent validity with the Braden (κ 0.74–0.81) and Norton (κ 0.72–0.73) scales, which were considered the gold-standard instruments.[16] The tool was later translated into English and tested in an Australian ICU, and demonstrated superior inter-rater reliability compared to the Braden Scale, Norton Scale, and Waterlow score (intraclass correlation [ICC] [2,1] 0.90 versus 0.66, 0.77, and 0.47, respectively). It was also strongly correlated to the Braden and Norton scores but was more perceptive to patient condition changes. Elsewhere, the COMHON Index has also been tested in terms of the commonly used predictive validity[16,17] and predictive validity with moving averages.[18,19] However, PI risk assessment tools do not 'predict' PI, and predictive validity is a flawed measure; if a tool effectively identifies risk and prompts the use of PI prevention measures, PI will theoretically be prevented and predictive validity confounded.[10,20]

More recently, the COMHON Index has been translated into Chinese Mandarin, with minor updates made to the English and Spanish versions (Version 2.1).[21] It was pretested in a Chinese ICU by 20 nurses who found the tool and its subscales easy-to-use and understand, with the majority of patient assessments taking 5 minutes or less. It has also since been translated into Turkish, following the same approach, and testing with nurses in a Turkish ICU demonstrated near-perfect inter-rater reliability (ICC [1, 1] = 0.998).[22] However, the Chinese Mandarin version has not yet undergone such testing. New translations of established tools require further psychometric testing before clinical use to verify reliability and validity in a new cultural context, even where previously determined for other language versions.[21,23] Inter-rater reliability and agreement is particularly important, as individuals may be assessed for PI risk using a tool by multiple differing clinicians, who are usually nurses, on a regular basis within clinical practice.[13,24] Convergent validity testing against established PI risk assessment tools, such as the Braden Scale commonly used in Chinese ICUs, is also required.

2. Objectives

The objectives were to:

- test and compare the inter-rater reliability of the Chinese Mandarin COMHON Index and Braden Scale with nurses in a Chinese ICU, and
- examine the convergent validity of the COMHON Index against the Braden Scale.

3. Methods

A reliability and validity study was undertaken. Reporting followed the Guidelines for Reporting Reliability and Agreement Studies (GRRAS; Supplementary file).[25]

3.1. Setting

Data collection was conducted in the 16-bed comprehensive ICU of an 1805-bed tertiary hospital in Beijing, China. The study ICU admits postoperative patients who are older, with underlying conditions, and who have undergone major surgery.

3.2. Participants

Nurse raters were required to assess the PI risk of a convenience sample of patients using both PI risk assessment instruments (COMHON Index, Braden Scale). Nurse raters were registered nurses with ≥6 months' experience working in the unit. Eligible patients were adults (aged ≥18 years) admitted to the unit with no current PI.

3.2.1. Sample size

The sample size calculation was based on a previous inter-rater reliability study conducted with four risk assessment scales, including the COMHON Index and Braden Scale, in which the same five nurse raters assessed each patient with both tools.[13] A larger number of raters is more closely aligned with clinical practice and decreases the possibility that statistical associations are reduced due to single-rater effects.[13] To be more feasible and representative of clinical practice, the five nurse raters differed between patients in this study.

To calculate the patient sample size, a minimum ICC of 0.60[26] with a top expected ICC of 0.80[13] was set. Using the sample size tables of Walter et al.,[27] with a nurse-rater sample size of five (κ = 5) to assess each patient, a patient sample size of 19.9 was required (α = 0.05, power = 80%).

3.3. PI risk assessment instruments

The Chinese Mandarin COMHON Index was used in this study (Version 2.1).[14,21] The COMHON Index provides instructions for raters to document subscale assessments, overall sum score, and risk level. The COMHON Index subscales (level of COnsciousness, Mobility, Haemodynamics, Oxygenation, Nutrition) are scored from 1 to 4, with criteria provided to guide the rating of each. The subscale scores are then summed (range 5–20), with sum scores equating to a level of PI risk (low 5–9; moderate 10–13; high 14–20).

For comparison to an established instrument, there is no tool that is regarded as the gold standard to assess PI risk.[28,29] Globally, however, the Braden Scale is widely used in the ICU, although it was developed for long-term care.[30] It is also widely used in Chinese ICUs, and as the standard care instrument in the study ICU, it was the established instrument used in this study. It measures six subscales: sensory perception, activity, mobility, moisture, nutrition, and friction and shear. The former five subscales are scored 1–4, whereas the friction and shear subscale is scored 1–3. Each subscale has defined criteria to inform rating. The sum score range is 6–23, with higher scores indicating lower risk (no risk 19–23; mild risk 15–18; moderate risk 13–14; high risk 10–12; very high risk ≤9).[31] For the purpose of this study, nurse raters were provided with a paper-based Chinese Mandarin Braden Scale, with written instructions to circle subscale assessments and document total sum score and circle risk level based on score on the data collection form.

3.4. Data collection

Data were collected between December 2023 and January 2024. On each data collection day, a nurse researcher identified eligible patients and nurses to participate. Data collection was conducted until the patient sample size of 20 was met. For nurse raters, baseline demographic data (age, qualifications, years of nursing practice overall and within the ICU) were collected, but personal details were anonymised. Patient demographic data (age, gender, admission diagnosis, International Classification of Diseases [ICD-10] code, Acute Physiology and Chronic Health Evaluation [APACHE] II score, skin status as per bedside nurse) were also collected. Consenting nurse raters assessed the PI risk of included patients using both the COMHON Index and Braden Scale. Assessments of each patient were conducted independently, within a 2-hour timeframe.

3.5. Data analysis

Data were entered into Microsoft Excel™ and IBM SPSS™ Statistics for Windows (Version 28, Armonk, NY: IBM Corp)[32] for analysis. Descriptive statistics using mean (M) with standard deviation (SD) and proportions (%) were used to describe the nurse rater and patient sample.

3.5.1. Inter-rater reliability

To measure inter-rater reliability for continuous data and repeated scale measurements, ICC is recommended.[33,34,35] For this study, ICC was calculated using a one-way random-effects model (1,1), which is appropriate where the raters differ for each subject.[33,36]

3.5.2. Agreement and minimally detectable change

Standard errors of measurement (SEM) and minimally detectable change (MDC) were also calculated.[13] The SEM of an instrument is important as it represents its absolute agreement. Provided it is smaller than a minimally important change (a change in score that would result in a change in the risk level), then the scale is able to distinguish clinically important changes.[37] The MDC indicates the minimum change in score that is required to indicate that a *real* change has occurred,[38] thus representing the smallest *true* change (which cannot then be due to measurement error).[13,37,39] Thus, a smaller MDC indicates a more sensitive measure.

To assess the risk-level agreement between the instruments, the Braden Scale was recoded into three risk-level categories (no/mild risk; moderate risk; high/very high risk). Rater agreement was analysed using weighted κ. Levels of agreement were interpreted as poor ($k < 0.00$), slight ($k = 0.00–0.20$), fair ($k = 0.21–0.40$), moderate ($k = 0.41–0.60$), substantial ($k = 0.61–0.80$), and almost perfect ($k = 0.81–1.00$).[40]

3.5.3. Convergent validity

To examine the convergent validity of the COMHON Index to the Braden Scale, sum scores were compared using Pearson Product Moment Correlation, whereas scale items (subscales) were compared using Spearman's rho. Correlation coefficients were interpreted as small ($r = 0.10$), moderate (medium, $r = 0.30$), and strong (large, $r \geq 0.50$).[41] Negative correlations were anticipated due to the reverse scoring of the Braden Scale.

3.5.4. Ethical approval

Ethical approval was received from the Ethics Committee for Peking University First Hospital (2023research360-002). A waiver of consent was approved for patient inclusion. Eligible nurses were informed of the study and provided voluntary written consent prior to participation.

4. Results

4.1. Participants

4.1.1. Nurse raters

A pool of 22 ICU nurses aged between 24 and 43 (M 31, SD 6) years participated. They had been practising in ICU for between 2 and 22 (M 8, SD 7) years. With each patient participant ($n = 20$) assessed independently by five nurse raters using both the COMHON Index and Braden Scale, there were a total of 100 assessments for each tool.

4.1.2. Patient characteristics

Patient participants had a wide variety of diagnoses (see Table 1), and none had a PI. Most were female ($n = 11$) and were aged between 54 and 86 (M 73, SD 9) years. Males were of similar ages (M 72, SD 13, range 42–88; $p = 0.792$). The patients' admission APACHE II scores ranged from 4 to 29, with females having higher scores (M 16.7, SD 6.4, range 11–29) than males (M 10.7, SD 3.3, range 4–14; $p = 0.009$).

4.1.3. Risk assessments

The mean (M) COMHON Index score for all assessments ($n = 100$) was 10.00 (SD 3.27, range 5–20) and the mean Braden score ($n = 100$) was 15.22 (SD 2.81, range 9–21). The risk levels determined by each tool are shown in Table 2a. With the Braden Scale recoded into three risk levels for comparison with the COMHON Index, there was 65% absolute agreement (see Table 2b) resulting in a weighted κ value of 0.53 ($p < 0.001$), indicating moderate agreement. The majority of patients assessed at moderate risk by the COMHON Index were assessed as no risk/mild risk by the Braden Scale (52.5%). A relatively large proportion of patients categorised as high/very high risk by the Braden Scale were moderate risk as per the COMHON Index (41.2%).

4.1.4. Inter-rater reliability

The sum, risk level, and item scores for both tools are shown in Table 3. Inter-rater reliability of the COMHON Index sum score was found to be very high (ICC [1,1] = 0.973 [95% confidence interval {CI}: 0.949–0.988]) with a small SEM of 0.54 and an MDC of 1.50. Inter-rater reliability of the Braden sum score was also high (ICC [1,1] = 0.891 [95% CI: 0.793–0.951]), with a relatively small SEM of 0.93 and an MDC of 2.57. All COMHON-index items demonstrated

Table 1
Patient characteristics.

Gender	Age	APACHE II score	Diagnosis	ICD-10 category
Male	64	9	Cervical spondylosis	XIII Diseases of the musculoskeletal system and connective tissue
	81	9	Renal neoplasm	II Neoplasms
	81	14	Septic shock	XVIII Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified
	42	4	Retroperitoneal tumour	XI Diseases of the digestive system
	76	9	Prostatic cancer	II Neoplasms
	67	14	Renal neoplasm	II Neoplasms
	88	14	Femoral neck fracture	XIX Injury, poisoning and certain other consequences of external causes
	76	12	Bladder stone	XIV Diseases of the genitourinary system
	74	11	Pituitary space occupying lesions	II Neoplasms
Female	66	15	Rectal hernia	II Neoplasms
	77	16	Gallstones with cholecystitis	XI Diseases of the digestive system
	69	29	Haemorrhagic shock	XVIII Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified
	76	15	Lower limb arterial embolism	IX Diseases of the circulatory system
	69	29	Urinary tract infection, perirenal infection, sepsis, heart failure	I Certain infectious and parasitic diseases
	71	11	Gastric adenocarcinoma	II Neoplasms
	83	15	Breast cancer	II Neoplasms
	54	11	Ureteral stenosis, hydronephrosis	XIV Diseases of the genitourinary system
	77	13	Adnexal mass	XIV Diseases of the genitourinary system
	80	13	Pulmonary space occupying lesion	X Diseases of the respiratory system
	86	17	Pulmonary oedema	X Diseases of the respiratory system

Abbreviations: APACHE: Acute Physiology and Chronic Health Evaluation; ICD: International Classification of Diseases.

Table 2a
Level of risk ($n = 100$).

Scale	Risk category *n* (%)				
	No risk	Low/mild	Moderate	High	Very high
COMHON Index	–	49 (49)	40 (40)	11 (11)	–
Braden Scale	11 (11)	53 (53)	19 (19)	13 (13)	4 (4)

Table 2b
Agreement of level of risk (three categories, $n = 100$).

	COMHON Index				
	Risk level	Low	Moderate	High	Totals
Braden Scale	No/mild	43	21	0	64
	Moderate	6	12	1	19
	High/very high	0	7	10	17
	Totals	49	40	11	100

Shaded cells = absolute agreements.

Table 3
Intraclass correlations ($k = 5$).

Risk assessment tool (score range)	ICC (1,1) (95% CI)	SEM (MDC)
COMHON Index		
Sum score (5–20)	0.973 (0.949–0.988)	0.54 (1.50)
Risk category (1–3)	0.911 (0.831–0.960)	0.20
Conscious level (1–4)	0.976 (0.953–0.989)	0.15
Mobility (1–4)	0.617 (0.271–0.829)	0.35
Haemodynamics (1–4)	0.951 (0.906–0.978)	0.18
Oxygenation (1–4)	0.955 (0.915–0.980)	0.20
Nutrition (1–4)	0.870 (0.753–0.942)	0.47
Braden Scale		
Sum score (6–23)	0.891 (0.793–0.951)	0.93 (2.57)
Risk category (1–5)	0.897 (0.805–0.954)	0.32
Sensory perception (1–4)	0.879 (0.770–0.946)	0.35
Moisture (1–4)	0.592 (0.224–0.818)	0.24
Activity (1–4)	0.523 (0.091–0.787)	0.34
Mobility (1–4)	0.848 (0.712–0.932)	0.32
Nutrition (1–4)	0.773 (0.567–0.898)	0.51
Friction and shear (1–3)	0.721 (0.468–0.875)	0.32

Abbreviations: CI: confidence interval; ICC: intraclass correlation; MDC: minimally detectable change; SEM: standard error of measurement.

ICC values above 0.6, whereas two Braden-Scale items (*Mobility*, *Activity*) were below this threshold.

4.1.5. Convergent validity

The COMHON Index and Braden Scale sum sores were strongly correlated (Pearson's $r = -0.76$ [$r^2 = 0.58$]; $p < 0.001$). Two items are common to both tools (*Mobility* and *Nutrition*), and one item from each tool assesses a similar construct (i.e., COMHON *Level of consciousness* and Braden *Sensory perception*). These three item pairs were all strongly correlated ($r_s = -0.56$ [$r^2 = 0.32$]; $r_s = -0.63$ [$r^2 = 0.39$]; $r_s = -0.67$ [$r^2 = 0.45$]; $p < 0.001$).

5. Discussion

The COMHON Index and Braden Scale both demonstrated high levels of inter-rater reliability in the ICU; however, further testing of their psychometric properties is recommended. There are only a few studies that have investigated the inter-rater reliability of PI risk assessment tools using ICC in the ICU. Values of ICC between 0.5 and 0.75 indicate moderate reliability,[42] although a minimum acceptable value of 0.60 has been proposed.[26] The very high inter-rater reliability of the COMHON Index in this study is consistent with recent testing of a Turkish version (ICC [1,1] 0.998; 95% CI: 0.996–0.999; SEM 0.14, MDC 0.39)[22] and an earlier Australian study using an English version (ICC [2,1] 0.90, 95% CI 0.65–0.95; SEM 1.32, MDC 3.65) compared to three well-established scales (Braden, Norton, and Waterlow).[13] In the latter study, inter-rater reliability of the Braden sum score was reported as ICC (2,1) 0.66 (95% CI 0.50–0.80; SEM 1.83, MDC 5.07), which is somewhat lower than that found in this study (ICC 0.89). The reasons for this are unclear, although it was possibly related to the nurse raters' familiarity with the Braden Scale as it was the standard practice instrument used in the study ICU, and across China. In a recent systematic review of the psychometric properties of the Braden Scale in the ICU,[43] only four studies were found that reported inter-rater reliability using ICC, ranging from 0.66[13] and 0.68[44] to 0.72 and 0.84,[33] and a very high

ICC of 0.96 (95% CI 0.83−1) was reported in a subset of three ICU patients.[45] Overall, the Braden Scale ICC found in our study compares favourably.

There was a strong correlation between the sum scores of the COMHON Index and Braden Scale ($r = -0.76$ [$r^2 = 0.58$]; $p < 0.001$). This is congruent with the convergent validity observed in another Chinese ICU with the same instruments ($r = -0.67$, $p < 0.001$)[46] and the Australian ICU with the English COMHON Index ($r = -0.70$, $p < 0.001$).[13] In comparison to the well-established scales tested by Fulbrook and Anderson,[13] the COMHON Index was less strongly correlated to the Norton ($r = -0.66$, $p < 0.001$) and not correlated with the Waterlow ($r = 0.10$, $p = 0.25$). These results indicate that the COMHON Index and Braden Scale overall are most similar in measuring constructs (i.e., PI risk) within the ICU. However, differences in subscale correlations between the COMHON Index and Braden Scale have been reported.[13,46]

Using the English versions, Fulbrook and Anderson[13] found strong correlations between the COMHON Index level of consciousness and Braden Scale sensory perception subscales ($r = -0.80$, $p < 0.001$) and mobility subscales ($r = -0.63$, $p < 0.001$), and moderate correlations between the nutrition subscales ($r = -0.46$, $p < 0.001$). Similarly, this study found that these three sets of subscales were all strongly correlated. In contrast, the study using the same Chinese Mandarin instruments found a strong correlation for only the COMHON Index level of consciousness and Braden Scale sensory perception subscales ($r = -0.64$, $p < 0.001$), while there was a small correlation between the mobility subscales ($r = -0.28$, $p = 0.014$).[46] Notably, a small and insignificant correlation was found between the nutrition subscales ($r = 0.07$, $p = 0.517$), with the positive direction of the correlation suggesting disagreement. The difference between studies may be due to variations in raters; in this study and in the Australian ICU, five nurse raters per patient conducted assessments, although it was the same nurse raters for each patient in Australia. In the latter Chinese study, only two raters conducted assessments per patient ($n = 100$) without a sample size calculation, which is less reflective of clinical practice.

Nonetheless, as the Braden Scale is not ICU-specific, it may not be sensitive to varying PI risk factors and levels within the ICU and instead categorises most ICU patients as being at higher PI risk.[47] Interestingly, over 60% of patients in this study were assessed by the Braden Scale to be at no or mild PI risk, but around 40% of patients categorised by the Braden Scale as high to very high risk were moderate-risk patients as per the COMHON Index. Similarly, the earlier study of the Chinese Mandarin COMHON Index also found differences in the categorisation of risk, with more patients assessed to be at low and moderate PI risk using the COMHON Index (62%) than the Braden Scale (40.1%), and less being at high risk as per the COMHON Index (38%) than at high and very high risk as per the Braden Scale (60%).[46] The contention that the Braden Scale may not be able to discriminate between levels of risk in the ICU is further supported by the calculation of measures of importance. The English[13] and Turkish[22] versions, along with the Chinese Mandarin COMHON Index in this study, have demonstrated smaller MDCs than the Braden Scale, indicating the former is more sensitive to small changes in patient condition and subsequently to levels of PI risk in the ICU. However, there is still a need to explore the influence of these instruments on preventative intervention use.[22]

6. Limitations

Only one ICU and an internal pool of nurse raters were included, limiting external validity. Further psychometric testing of the Chinese Mandarin COMHON Index, particularly in relation to inter-rater reliability with ICCs in other ICUs, is recommended. Nurses were experienced in using the Chinese Mandarin Braden Scale in standard practice, although the data collection tool differed in presentation, but training was not provided for the COMHON Index, given that it is easy-to-use and understand.[21] This may have impacted the results.

7. Conclusion

Both the COMHON Index and the Braden Scale have high levels of inter-rater reliability in the ICU, but the COMHON Index has demonstrated superiority. Furthermore, while strong convergent validity indicates the instruments measure similar constructs, the COMHON Index may be more sensitive to changes in patient condition and varying PI risk levels in the ICU. This is significant; while the Braden Scale is widely used in this context, the results supporting the freely available COMHON Index were favourable. Nevertheless, further psychometric testing across different ICUs, and the influence of the instruments on preventative intervention use, is recommended.

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CrediT authorship contribution statement

Josephine Lovegrove: conceptualisation, methodology, project administration, resources, validation, visualisation, writing—original draft, writing—review and editing. **Paul Fulbrook**: conceptualisation, methodology, formal analysis, resources, supervision, validation, visualisation, writing—original draft, writing—review and editing. **Cui Yuan**: data curation, investigation, resources, validation, writing—review and editing. **Frances Lin**: project administration, validation, writing—review and editing. **Xian-Ling Liu**: conceptualisation, methodology, resources, validation, writing—review and editing.

Conflict of interest

None.

Data availability statement

Data available on request from the authors.

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Supplementary data

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