



Instruments to collect primary data on the worker stakeholder: short versions and application guidelines

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Abstract

Purpose This study aims to address the lack of standardised and comparable primary data collection procedures in Social Life Cycle Assessment (S-LCA) by developing shortened versions of 14 previously established scales for assessing worker-related subcategories. The objective is to reduce data collection time and resource requirements while maintaining the original scales' reliability and goodness-of-fit.

Method The method comprised an iterative approach of applying network and exploratory factor analyses to screen for the most representative items, of each social phenomenon, with better loading factors. The reduced version of the instruments were applied to five samples containing 289 to 549 workers from over 50 industries and various job positions for conducting the Confirmatory Factor Analysis (CFA).

Results and Discussion The study resulted in a set of 14 instruments comprising 39 indicators, grounded in ILO conventions and recommendations as well as established literature across various social science fields. These instruments are applicable across different working contexts, economic sectors, and countries. CFA demonstrated adequate to predominantly excellent model fit and reliability indices for all instruments and their respective indicators. In addition to the instruments themselves, application guidelines and further methodological recommendations were developed to support S-LCA practitioners. While primarily designed for social sustainability assessment within S-LCA, the instruments also show potential applicability beyond this scope, including use by policymakers, human resource professionals, and non-governmental organisations.

Conclusion This study had the limitation of being applied only in the Brazilian scope, which points to the potential of further investigations to verify whether the same ranges for goodness-of-fit and reliability indices are found in cross-cultural studies.

Keywords Social life cycle assessment · Worker · Primary data · Data collection · Social life cycle inventory

1 Introduction

Within the Social Life Cycle Assessment (S-LCA) scope, the concept of *Decent Work*, as defined by the International Labour Organisation (ILO, 1999) serves as a guiding axis for assessing the worker stakeholder in S-LCA. 1999, representing the aspirations people have for their working lives. The Decent Work concept encompasses a productive activity that offers fair remuneration, workplace safety, social

protection for families, social integration, opportunities for personal development, freedom to express concerns, organize, and participate in decisions that affect one's life, and equality of opportunity and treatment for all, regardless of gender (ILO, 1999).

ILO established four strategic objectives for countries and institutions to implement operational actions that promote Decent Work: (1) Respect for labour rights, including freedom of association, the right to collective bargaining, elimination of discrimination in employment and occupation, and eradication of all forms of forced and child labour; (2) Promotion of productive and high-quality employment; (3) The expansion of social protection, and (4) The reinforcement of social dialogue (ILO, 2013). Therefore, Decent Work represents not only a human-centered vision of work, but also a cornerstone for sustainable development and inclusive and equitable growth.

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The four strategic pillars of decent work are further elaborated into ten key elements that form the Decent Work Agenda: (1) Full and productive employment; (2) Labour rights; (3) Protection and promotion of social dialogue; (4) Work-life balance; (5) Elimination of unacceptable forms of work; (6) Employment stability and security; (7) Equality of opportunity and treatment; (8) Safe and healthy working environments; (9) Social security; and (10) Social dialogue and representation of workers and employers (ILO, 2013). Accordingly, Goal 8 of the United Nations Sustainable Development Goals (SDGs) explicitly calls for the promotion of sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all (United Nations, 2015).

ILO has been instrumental in both conceptualizing and advancing this goal through several work-related studies throughout the world. Moreover, it elaborates standards present in conventions relating to the multiple core themes that Decent Work encompasses. In parallel, it elaborates recommendations that offer principles and guidance to countries around the world, encouraging the adoption of policies that focus on promoting a more just and equitable society. ILO also carries out field assessments and thematic studies at regional, national, and sectoral levels, with the goals of identifying rights violations, deepening the understanding of specific issues, disseminating knowledge, and indicating critical areas where decent work remains unrealized.

Consequently, the majority of these themes directly correspond to the issues covered under the eleven subcategories constituting the “worker” stakeholder group defined in the Guidelines for Social Life Cycle Assessment of Products and Organizations - S-LCA Guidelines, for short (UNEP, 2020). In addition, the Methodological Sheets for Subcategories in Social Life Cycle Assessment (UNEP, 2021) recommend the adoption of the theoretical and conceptual framework found in ILO conventions, recommendations, and reports. It is important to emphasize that S-LCA not only incorporates the concept of decent work, but also expands upon it, encompassing the full breadth of labour-related analyses addressed by the ILO, while advocating for an in-depth and comprehensive study of each topic, taking into account all of its possible dimensions.

The ILO’s framework covers each of the impact subcategories related to the stakeholder worker and, depending on the theme, indicates minimum and maximum legal thresholds for the signatory countries, according to their respective levels of socioeconomic development. In addition, the framework offers theoretical definitions and analytical guidelines that allow for consistency and comparability across studies and assessments in the field.

Given its great importance, workers are the most frequently assessed group in S-LCA case studies (Petti et al.

2018; Rebolledo-Leiva et al. 2023). Their views and narratives directly reflect the behaviour of the work organisations, indicating how they deal with social aspects, such as working conditions, labour rights and wellbeing. Moreover, workers are usually the most reachable group when collecting primary data, generally in the foreground system (Petti et al. 2018; UNEP, 2020).

In a S-LCA, primary data is deemed as the most relevant and accurate to represent and investigate the social aspects related to creating a product throughout its entire life cycle. The S-LCA Guidelines states that primary data is especially relevant for better depicting the reality of the social issues or the positive impacts in the foreground processes (UNEP, 2020), where the organisations typically have a direct influence on the social impacts. Primary data offers a direct and context-specific representation of the social conditions, while allowing for hearing the voices and the claims of the impacted people.

The process of data collection includes interviews, surveys, or other participatory methods that engage both the S-LCA practitioner and stakeholders. It gives a unique opportunity to deepen the understanding of the socioeconomic and cultural conditions and contrasts, giving a genuine space to voice concerns and opportunities. Despite its promising character, primary data may pose several challenges in the collection process, such as being time and resource-consuming, difficulties in reaching and engaging stakeholders, selection and application of adequate data collection instruments, among others. Beyond that, the S-LCA Guidelines (UNEP, 2020) also highlight the great challenge of covering the entire value chain when collecting primary or site-specific data.

To address these methodological barriers while advancing a comprehensive and reliable assessment of workers’ conditions, a set of 14 psychometric instruments was developed (Chabrawi et al. 2024), covering all aspects entailed in the concept of Decent Work, as defined by the International Labour Organization (ILO, 1999). The 14 instruments address the following topics: 1. Forced Labour; 2. Child Labour; 3. Freedom of Association and Collective Bargaining; 4. Fair Salary; 5. Social Security and Social Benefits; 6. Discrimination and Equal Opportunities; 7. Working Hours; 8. Health and Safety; 9. Employment Relationship; 10. Sexual Harassment; 11. Working Relationship; 12. Recognition at Work; 13. Remote Work; and 14. Bullying in the Workplace. The topics from 1 to 10 relate to the impact subcategories proposed in the S-LCA Guidelines (UNEP, 2020), while topics 11 to 14 were introduced by Chabrawi et al. (2024) as new subcategories, not previously foreseen in the S-LCA Guidelines, due to their high relevance in contemporary working contexts.

For a commonly grounded approach to assess different impact subcategories across various work positions, and different countries that carry various socioeconomic and cultural conditions, the development of the assessment instruments was built upon the conceptual framework proposed by the ILO and other UN bodies, e.g., UNICEF (Table 6). This means that every social indicator and each of its corresponding items were defined and framed according to the definitions and requirements outlined by the ILO and UN bodies to meet the requirements present in the concept of Decent Work. In other words, the instruments were designed to align with international standards on working conditions, ensuring their applicability across both developing and developed countries. Additionally, focus groups were conducted with a wide variety of workers from multiple working backgrounds to deeply and sharply frame the items of each instrument.

These instruments are also named as multi-item scale¹, or just “scale” for short. The scales were first developed as long versions, comprising several items that aimed at covering a large extent of measuring each impact subcategory. Although comprehensive, the wider the questionnaire, the longer the response time, causing possible respondents’ dropouts, fatigue, and a smaller number of participants. Challenges regarding the length and intensity of the work (Dreyer et al. 2010; Sala et al. 2015; Grubert 2018; Pollok et al. 2021) have been one of the major issues of rigour in data collection, and still are to the present day.

In a context of collecting a multitude of data, regarding different social phenomena, and with various stakeholders, shorter but accurate versions of assessment instruments are crucial to guaranteeing primary data collection, without compromising a truthful assessment coverage (Mourão et al. 2022). On the one hand, long instruments cover a wider spectrum of the phenomenon to be measured, where each item assesses just a small fraction of the sphere of behaviour, perception, etc. (Tambs and Røysamb 2014). On the other hand, brief versions of the same instrument can significantly reduce the time spent collecting and analysing data, and they require fewer cognitive resources from respondents, making the task easier and more practical (Kemper et al. 2019). When properly built, a short version should present all the evidence of validity and factor reliability (indicators) of the long version (Smith et al. 2000).

Aiming to dispense with part of the burden of primary data collection, while ensuring data consistency and reliability, this work focused at reducing the long-versions of the scales developed previously by Chabrawi et al. (2024). This work also offers an extensive and structured literature

review addressing the challenges of data collection, the scarcity of reliable instruments for primary data collection, and the lack of harmonised indicators in S-LCA. Furthermore, it presents the methodological foundations of Psychometrics and scale development, highlighting the importance of applying appropriate methods and tools when developing such instruments. Accordingly, readers are referred to Chabrawi et al. (2024) for additional contextual and methodological background, particularly to support a deeper understanding of the Method section and to obtain detailed guidance on the application of the instruments, whether used individually or in combination.

Since this study is primarily intended for social sustainability practitioners, it intentionally briefly presents the methodological and psychometric tools used for the scales’ reduction. Thus, it offers only a concise overview of the techniques borrowed from the field of Psychometrics to create a short version of the scales. Likewise, it addresses the goodness-of-fit and reliability indices yielded during the reduction process by reporting only the range of values obtained throughout the 14 scales, and the corresponding thresholds for interpreting their adequacy. This approach seeks to balance the necessary rigor in reporting scientific studies, ensuring that all relevant information is being conveyed, while communicating it with parsimony and focusing on practical applicability guidance for S-LCA case studies. More detailed psychometric procedures and results may be reported in future or complementary publications, where relevant.

This paper is organised as follows. Section 2 presents the methodological approach, detailing the procedures adopted to reduce the original instruments and to test the robustness of the short versions. In particular, Sect. 2.1 describes the item-reduction procedure, including the multi-step analytical strategy; Sect. 2.2 outlines the sample characteristics and data collection process; and Sect. 2.3 explains the statistical analyses, focusing on Confirmatory Factor Analysis and the goodness-of-fit and reliability indices applied. Section 3 presents the results, structured into Sect. 3.1, which reports the fit and reliability indices of the reduced instruments, and Sect. 3.2, that presents the final set of indicators, their definitions, and the comparison in terms of items count between long and short versions. Section 4 discusses the findings, addressing their implications for S-LCA practice, the applicability of the instruments across contexts, and methodological considerations related to primary data collection and interpretation. Section 4.1 presents general and specific application guidelines and recommendations. Section 4.2 elaborates on the impact assessment approaches using the results from the scales, aggregation and weighting options and, finally, Sect. 4.3 presents potential limitations related to the scales. Lastly, Sect. 5 concludes the

¹ A multi-item scale is an assessment tool that measures the information of social or behavioural phenomena at the individual or societal levels in a reliable and valid way (Kline 2013).

paper, summarising the main contributions, and pathways for future research.

2 Method

The method for reducing the long version of the 14 scales consisted of a multi-level approach, organised in the topics 2.1 to 2.3. It covers the six-step approach to analyse and remove the items, the general description of all samples and the rationale for data analysis. A visual summary of the decision process is presented in Fig. 1 to improve clarity and understanding. Further details on Psychometrics, scale development, and the statistical procedures and adjustment indices for Exploratory and Confirmatory Factor Analysis (EFA and CFA), and reliability indices are provided in Chabrawi et al. (2024) and are only briefly summarized here to maintain focus on the reduction method.

2.1 Procedures

Six steps were used to derive the 14 reduced scales, as summarised in Fig. 1, encompassing three complementary levels of analysis: network analysis, factor loadings and communalities, and model goodness-of-fit of each scale. Network analysis was used to examine the pattern and strength of inter-item relationships within each scale. Factor loadings

and communalities were verified to assess the extent to which each item contributed to measuring the construct. Finally, goodness-of-fit indices examined how well the scale (set of items) fit the underlying measurement model. These three analytical levels were combined in an iterative way to inform optimal item-retention and exclusion decisions. After removing the items, the reduced versions were applied again to verify the stability of their internal structure, including goodness-of-fit indices, factor loadings, and communalities.

Initially, a network analysis was carried out to execute the **first step**. A network analysis is a graphical representation of the relationship between different variables and their mutual influence (De Schryver et al. 2015). It provides the ability to estimate complex patterns of relationships and the network structure (Hevey 2018). For better clarity, in the present study, the variables were the items, and how they related to each other represented the relationship among the variables.

The verification of which items to discard was based on the analysis of three measures of centrality: betweenness (the degree to which an item is connected with others), closeness (a measure of the distance of an item to all others - the more central the item in the graphical representation, the closer it is to all the others), and strength (measures the strength between items) (Leme et al. 2020). These indices were calculated within a network analysis framework, in which each item was treated as a node and the correlations between items as edges. Whenever items are well integrated with high betweenness, closeness and strength, they will form a network of items (nodes). Each network represents the factor (indicator) to which the items are measuring. Scales with more than one indicator will show a graphical representation of clusters as many as the number of indicators. Items with low betweenness, closeness, and strength will appear farer from the group of items it belongs and, therefore, be candidate for removal, as it is less integrated within the network structure and exhibited weaker associations with the remaining items, indicating a lower contribution to the underlying construct.

The network analysis was conducted on the software JASP version 0.19.3. The centrality indices were computed separately for each scale based on the polychoric correlation matrix, which is appropriate for ordinal Likert type of data. To operationalise item exclusion in a reproducible manner, all centrality scores were standardized (z-scores), and items with values below -1 standard deviation on at least two of the three indices were flagged for potential removal. This decision rule ensured that item exclusion was driven by convergent evidence across multiple network properties, rather than by a single metric. Flagged items were not

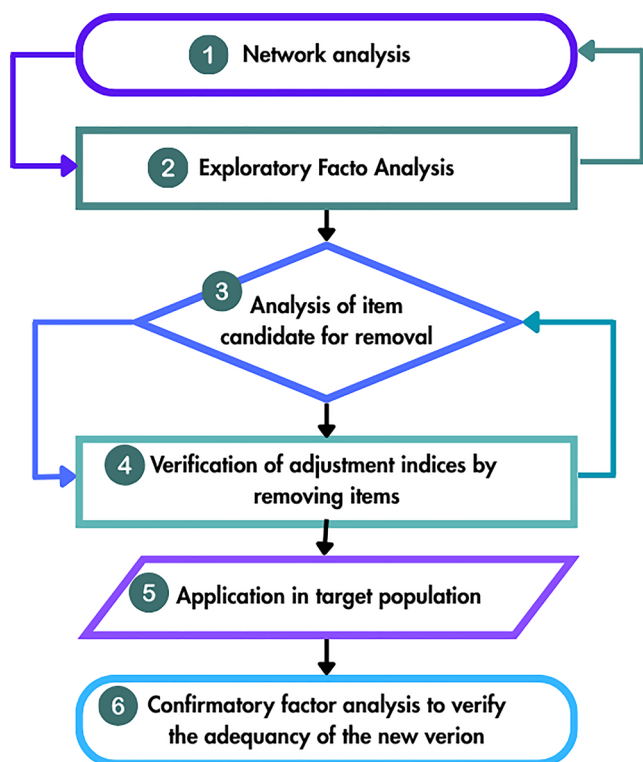


Fig. 1 Flowchart of the decision process for item exclusion

automatically removed, but instead, carried forward to the second step for confirmation.

In the **second step**, an EFA was performed for each scale using the full (long) version of the instruments to examine the item's factor loading (the extent to which an item is related and how well it represents the construct, e.g., forced labour), and their communality (how much the item explains the intended construct). This step of relevant for bringing another two types of measure for deciding on the removal of items. In other words, not only how an item is well integrated with the other items is observed, but also how much it explains the indicator and the extent to which it measures the construct (impact subcategory). This procedure ensured that the decision for item exclusion was guided by both quantitative evidence and theoretical interpretability, maintaining the internal coherence and construct validity of the reduced versions.

Once results from the network analysis and the EFA were obtained and gathered, the **third step** comprised analysing the list of items that were flagged for removal against the respective factor loading and communality to confirm their exclusion. While items with loadings below 0.40 are indicated for removal (Hair et al. 2010), this study applied a more rigorous approach for discarding items with loadings below 0.50 or 0.60, due to the fact that the items of the long version had overall high factor loadings, which means they were good measures overall.

As a **fourth step**, the model of fit of each scale was iteratively re-evaluated after each item removal, allowing only one item to be removed at a time. The model of fit comprises a set of goodness-of-fit indices that measures how well a scale, which is made up of several items, actually measures the construct it is supposed to measure. More information about the goodness-of-fit indices can be found in Chabrawi et al. (2024). After each iteration, goodness-of-fit indices were recalculated by running the EFA at each time, and compared against established thresholds (Table 2). If the removal of an item resulted in fit indices falling below acceptable levels, the item was retained. Conversely, when item exclusion maintained or improved model fit, the removal was confirmed. This stepwise approach explains why some scales allowed for more extensive reduction than others and ensured traceability of all exclusion decisions. Factor loadings, goodness-of-fit and reliability indices are common outputs yielded in an EFA, and they were also computed using the software JASP version 0.19.3. Further details about EFA are provided in Chabrawi et al. (2024).

The **fifth step** comprised the application in the target population (Sect. 2.2) to verify whether the internal structure of each instrument was preserved in comparison with the original versions. Lastly, in **sixth step**, an CFA was conducted to verify the goodness-of-fit and reliability indices of

the reduced versions to confirm their adequacy and goodness-of-fit, as well as the reliability of each indicator. This step is explained in more detail in topic.

2.2 Sample description

After the full development of the long version of the 14 scales, an exclusive round of application with the short version was conducted to verify whether the good-to-excellent goodness-of-fit and reliability indices would be found. In other words, if the short version of each assessment instrument works as well as the long ones. The strategy for applying the instruments sought to maximise the number of respondents per application, i.e., five links with 3 to 5 instruments were sent to a database of workers (Chabrawi et al. 2024). It was considered a valid response to those to whom the participant responded to all instruments, including the sociodemographic questionnaire. The sample description is presented as ranges in terms of numbers or percentages, provided in Table 1.

The analysis of the ranges showed that the five samples comprised a diverse variety of workers, ranging from 289 to 549 participants. In terms of gender, a balanced distribution is noticed with 42% of women, where non-binary (0,2%) and other (1,2%) indicate the representation of diverse gender identities. The majority within the samples is white and brown people, with almost 40% each. Black people varied from 13% to 16%. Most of the participants reported receiving up to 3 minimum salaries, although higher incomes were also significantly distributed among the samples. In terms of working hours, full-time was almost three times higher than part-time contracts, with participants predominantly working on-site. Remote (8% – 13%) and hybrid work (5% – 9%) took a smaller share of the working arrangement. More than half of the workers reported having a formal contract, while informal contracts represented more than 10% in range. Most of the participants worked in large or medium-sized companies, and the hierarchical level showed a wide variety of positions, ranging from directors and other managerial positions to apprentices and interns.

2.3 Data analysis

Following the items reduction and the application of the short versions, an CFA was conducted to verify whether the internal structure of the scales, i.e., the relationship of the items and their corresponding indicators, as well as the adequate fit and reliability indices were preserved. In other words, the objective was to verify if reducing the scales to lesser items did not affect the quality and precision of the instruments. The procedures applied to conduct the CFA followed those described in Chabrawi et al. (2024). The

Table 1 Samples' description by ranges

Participants 289–549					Living zone Urban: 94% –96% Rural: 4%–6%
Gender Female: 42%–52% Male: 48%–57% Non-binary: 0,2% Other: 0,2%–1,2%					
Ethnicity Black: 13%–16% –0,6% Brown: 38%–41% Other: 0,1%–1,5% White: 39%–47% Asian: 0,3%–0,6% Indigenous: 0.5%					
Education Primary: 5%–10% Secondary: 30%–44% Higher: 34%–42% Postgraduate: 14%–23%					
Income: Up to min. salary: 26%–35% –3% 1–3 min.: 43%–49% >20 min: 0,3%–0,6% 3–5 min: 10%–15% 5–10 min.: 5%–9% 10–20 min.: 2%					
Working hours Full-time: 66%–72% Part-time: 22%–27% Night-time: 5%–12%					Working arrangement On-site: 79% –86% Remote: 8%–13% Hybrid: 5% –9%
Employment relationship Formal contract: 53%–63% –6% Other: 15%–21% Informal contract: 12%–16% Legal entity: 2%–5% Individual taxpayer: 4%					
Company size Large: 37%–47% –14% Medium: 22%–25% Small: 13%–17% Microbusiness: 8%–11% Microentrepreneur: 7%					
Hierarchical level Director: 0.3%–3% –14% Manager: 4%–5% Assistant: 17%–20% Apprentice: 1%–5% Supervisor: 4%–6% Administrative: 6.9%–9.4% Intern: 1%–7% Other: Consultant: 2%–3% Operator: 13%–16% Analyst: 4%–8% Technician: 8% Spe-					

objectives, rationale, and interpretation guidelines for fit and reliability indices can be consulted in that work.

However, for convenience, a brief definition and the main threshold values used to interpret the CFA results of the reduced scales are restated below to facilitate reference and ensure clarity. The respective goodness-of-fit indices were analysed: Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Square Residual (SMSR), Comparative Fit Index (CFI), and Tucker Lewis Index (TLI). Finally, four types of reliability indices for each indicator of all 14 scales were verified.

As a brief explanation, RMSEA and SRMR are error indices that reflect how well the predicted relationships between the items and their corresponding construct (indicator) align with the actual relationships found in the collected data. Lower values indicate smaller errors and a better fit of the model (instrument) (Hu and Bentler 1999). CFI and TLI compare how well the model (instrument) explains the data against a hypothetical model that assumes nothing is connected or related. The scores vary from 0 to 1, where values closer to 1 are desired, meaning that the proposed model (instrument) explains the data structure better. As for the chi-squared (χ^2), it measures how much the estimations of the model differ from the actual data, where smaller values indicate a closer fit. However, because chi-squared is often

Table 2 Goodness-of-fit indices thresholds

χ^2 /gl:	< 5, preferably < 3 (Brown 2015)
CFI	> 0.90, preferably, ≥ 0.95 (Hu and Bentler 1999)
TLI	> 0.90, preferably, ≥ 0.95 (Hu and Bentler 1999)
RMSEA	≤ 0.05 close fit ≤ 0.08 fair fit (Browne and Cudeck 1993)
SRMR	< 0.10 (Hair et al. 2009)

Table 3 Reliability indices thresholds

Composite reliability	> 0.80 (Raykov 1997)
Cronbach's alpha	> 0.70 acceptable ≥ 0.80 good ≥ 0.90 excellent (Cortina, 1993)
McDonald omega	> 0.70 acceptable ≥ 0.80 good ≥ 0.90 excellent (Cortina, 1993)
Guttman's lambda	> 0.70 acceptable ≥ 0.80 good ≥ 0.90 excellent (Guttman 1945)

increasing with larger samples, it is usually considered the ratio chi-squared to its degrees of freedom (χ^2/df). For an instrument to be considered a good fit, the aforementioned indices should meet the thresholds introduced in Table 2.

Regarding reliability indices, Cronbach's alpha, McDonald's omega, composite reliability, and Guttman's Lambda 2 were all assessed. These indices measure the internal consistency of the indicators (factors) and how reliable they are in measuring the corresponding social phenomena. The interpretation of the reliability indices is provided in Table 3.

Table 4 Ranges of the indices of goodness-of-fit for all 14 scales

	χ^2	χ^2/df	CFI	TLI	SRMR	RMSEA (90% CI)
Ranges for all indicators	34.78–529.6	1.7–3.67	0.97–1.00	0.96–1.00	0.025–0.07	0.045–0.081

NB. χ^2 =chi-squared; df =degrees of freedom; CFI=Comparative Fit Index; TLI=Tucker-Lewis Index; SRMR=Standardized Root Mean Square Residual; RMSEA=Root Mean Square Error of Approximation; ** $p<0.001$

Table 5 Ranges of the reliability indices for all 14 scales

	Composite Reliability	McDonald's Omega (95% CI)	Cronbach's Alpha (95% CI)	Guttman's Lambda 2 (95% CI)
Ranges for all indicators	0.728–0.981	0.707–0.977	0.682–0.977	0.692–0.977

3 Results

The results of this study are presented in two parts. Section 3.1 focused on reporting the main results of the CFA conducted for the 14 scales, in which two tables are presented: one with the ranges for the goodness-of-fit indices (Table 4) and another with the reliability indices (Table 5). The index values are presented as minimum and maximum ranges identified in each analysis. Only these ranges are reported, as providing the full dataset for each scale would be excessively extensive and offer limited additional value for the scope of this paper. Instead, the complete data related to the development and reduction of each scale will be presented in separate publications. In Sect. 3.2, the definitions of the final list of indicators are introduced in Table 6 to guide S-LCA practitioners on what social aspects are entailed within each indicator. Finally, Table 7 displays the list indicator per number of items in the original long versions and the respective numbers in the short versions.

3.1 Goodness-of-fit and reliability indices

The CFA was carried out to verify whether the high-quality fit indices observed in the long versions were preserved in the short versions, and to confirm the factor structure of the reduced scales. The factor structure indicates which items load onto each indicator (factor). Accordingly, the analysis examined whether the items' assignment to a specific indicator remained consistent to the original versions.

For interpreting the index ranges, the threshold criteria provided in Tables 2 and 3 should be consulted. For example, both CFI and TLI values should be at least above 0.90 and preferably higher than 0.95. As shown in Table 4, the range values obtained for all 14 scales were between 0.97 and 1.00 for the CFI and between 0.96 and 1.0 for the TLI, indicating excellent fit. The same rationale applies to the interpretation of the remaining indices. Presenting the indices as ranges offers an overview of the robustness of the instruments developed to capture subjective information in an objective and reliable manner. The range values for all fit indices across the 14 scales were within ideal thresholds, demonstrating the preservation of the internal structures,

and confirming an optimal data fit for the original model of the scales.

Lastly, Table 5 presents the range of the reliability indices for all the reduced versions of the scales. Such as in the long version, the reduced ones presented good to excellent indices, as well as the minimum and maximum values for the confidence interval, attesting to the reliability and replicability of the short versions of the instruments.

3.2 Indicators, definitions, and number of items

As informed in the introduction, all scales were developed primarily based on the standards and norms foreseen in ILO conventions and recommendations, or on other relevant reports related to UN organizations, as indicated in Table 6. The proposed new subcategories were based on literature related fields of knowledge, such as Work Psychology. The main references that served as subsidies to develop each instrument are also indicated in Table 6. Since not all social constructs encompass the same level of complexity, different numbers of indicators were assigned to each impact subcategory. As detailed in Chabrawi et al. (2024), the number of indicators was initially hypothesized based on theoretical grounds and subsequently tested through an EFA to confirm the number of indicators within each subcategory. Table 6 presents the final set of indicators and their respective definitions.

Similarly, the indicators have varied considerably in the number of items, even within the same impact subcategory. This variation reflects differences in the complexity and social dimensions each indicator aims to capture. Thus, depending on the construct, more items were necessary to ensure an accurate assessment of the underlying phenomenon in real work contexts. Each indicator definition was elaborated to reflect the main aspects outlined in ILO documents, and secure cross-countries application and comparability. Moreover, related literature coming from Work Psychology was applied for three of the newly proposed subcategories: Working Relationship, Recognition at Work and Bullying in the Workplace. The later was also based on Work Psychology and on the Violence and Harassment Convention n° 190 (ILO, 2019a). The complete list of references

Table 6 List of indicators and their definitions

Subcategory	Indicator	Definitions	References
1. Forced Labour	Involuntary nature and maintenance of forced labour	Encompasses all means to subject workers involuntarily or to maintain them working under coercion. It may include threats or use of physical or psychological violence, sexual abuse, deprivation of basic rights, restriction of movement, and threats to workers or their families. Examples include children born into slavery, selling people into slavery, kidnapping for forced labour, induced debt that obliges an individual to engage in forced labour, false and misleading promises of work that ends in forced labour, withholding or non-payment of wages, and retention of documents and personal items as a way of inducing a person into forced labour.	<i>Forced Labour Convention</i> , C029, <i>Abolition of Forced Labour Convention</i> , C105, <i>Forced Labour (Indirect Compulsion) Recommendation</i> , R035, <i>Forced Labour (Supplementary Measures) Recommendation</i> , R203, International Labour Organization (ILO)
2. Child Labour	Light work	Refers to the paid work performed by children, which does not harm their health and development, and the working hours do not affect school attendance. It may be carried out by children aged 13 to 15 (or 12 to 14 in developing countries, as per national legislation). It is regulated and, therefore, the employer checks the age of the children before hiring them.	<i>Minimum Age Convention</i> , C138, <i>Worst Forms of Child Labour Convention</i> , C182, <i>Minimum Age Recommendation</i> , R146, <i>Worst Forms of Child Labour Recommendation</i> , R190, International Labour Organization (ILO);
	Hazardous work	Refers to the paid work performed by children under the age of 18 in economic activities that can affect their physical, social, or mental health. It involves long working hours and impacts school attendance, potentially leading to school dropout. Working conditions are unsafe and unhealthy, and include long working hours, exposure to abuse or exploitation, and the work is degrading.	<i>Child Labour Recommendation</i> , R190, International Labour Organization (ILO);
	The worst forms of child labour	Work carried out by children under the age of 18 that exposes them to practices that include one or more of the following conditions: involuntary work, threats, slavery, prostitution, sexual and other types of violence (physical and verbal), human trafficking, trafficking of drugs and illicit substances, and other illegal activities.	<i>Child Labour Global Estimates</i> , 2024, United Nations International Children's Emergency Fund (UNICEF)
3. Freedom of Association and Collective Bargaining	Trade unionism	Rights of employers and workers to conceive and join any type of organisation, without prior authorisation from employers, the State or other authorities, in order to provide and maintain interests and rights, as well as to establish collective agreements between the parties, with the guarantee of not having as a consequence any type of punishment, retaliation, direct or indirect harm to workers.	<i>Freedom of Association and Protection of the Right to Organise Convention</i> , C087, <i>Right to Organise and Collective Bargaining Convention</i> , C098, International Labour Organization (ILO)
	Collective bargaining	Corresponds to negotiations carried out between employer(s) or association(s) of employer(s) and workers, or workers' association, aimed at establishing working conditions, terms of employment, regulating relations between employees and employers (or employers' associations), as well as other improvements related to the working context. The bargaining may not result in any direct or indirect punishment, retaliation, or harm inflicted by the employer.	
4. Fair Salary	Living wage	Wage that meets the workers and their family's needs regarding food, shelter, transportation, health, among others, and their sociocultural needs, considered acceptable by society given the local economy.	<i>Equal Remuneration Convention</i> , C100, <i>Protection of Wages Convention</i> , C095, <i>Minimum Wage Fixing Convention</i> , C131, <i>Protection of Wages Recommendation</i> , R085, <i>Minimum Wage Fixing Recommendation</i> , R135, International Labour Organization (ILO)
	Equal pay	Right to remuneration compatible with the position held and equivalent to that of professionals occupying the same or similar positions, in terms of tasks, complexity, and responsibility, regardless of gender, religion, sexual orientation, ethnic origin, ideology, or appearance.	
	Equitable salary	Remuneration corresponding, at least, to the salary floor of the professional category, added to the extras due, according to the country's legislation. It must also consider the workers' skills and qualifications, their responsibilities related to assets and people; physical, mental, and psychosocial effort; and physical and psychological conditions required by the position.	

Table 6 (continued)

Subcategory	Indicator	Definitions	References
5. Working Hours	Workday flexibility	Relates to workday arrangements and flexibility, according to the specific needs of workers. The arrangements should be flexible enough to accommodate workers' individual needs while respecting maximum hour limits, guaranteed daily and weekly rest, and special protections for night work in line with international labour standards	<i>Hours of Work Convention, C030, Holidays with Pay Convention, C132, Weekly Rest Convention, C106, Forty-Hour Week Convention, C047, Weekly Rest Recommendation, R103, Part-Time Work Recommendation, R182, Reduction of Hours of Work Recommendation, R116, Holidays with Pay Recommendation, R098, International Labour Organization (ILO)</i>
	Paid rest	Comprises both weekly and annual paid leave. Workers must receive at least 24 consecutive hours of rest in each seven-day cycle, insofar as practicable, to accommodate their cultural and religious needs. Annual paid leave should comprise a minimum of three working weeks paid annual leave after twelve months of service. All rest periods must be paid at a rate no less than the worker's normal remuneration (including regular allowances), and scheduled and disbursed in line with national law and practice.	
	Working hours regulation	National laws on working time have specific daily and weekly limits that should not be exceeded. Additional hours must be treated as overtime and dealt in a compliant way, according to the national regulations on overtime. Furthermore, working hours must not exceed what is contractually agreed, even when not exceeding the national laws, and likewise, should be treated as overtime.	
	Overtime	Hours worked in addition to those defined in a contract or employment agreement that must be compensated through remuneration or rest. If compensation occurs via remuneration, this should not be less than the amount defined by the law of the country in question. Overtime also must not exceed the maximum hours defined by the labour legislation of each country.	
6. Remote Work	Remote workday	Remote working arrangement that refers to: (1) working shift, workload, and number of hours worked; (2) type of remote work carried out: occasional, additional, partial, or substitutive; (3) diverse options for flexible working hours, and whether positive or negative for the worker.	<i>ILO, 2021a; ILO, 2021b; ILO; ILO, 2022a; 2022b; Home work Convention, C177; ILO, 1996; Workers with Family Responsibilities Convention, C156; ILO, 2022b.</i>
	Work-life balance	The interaction of work dynamics and management styles practiced by the organisation, in combination with individual life circumstances and personal life, can lead to either positive or negative work-life balance. When applied to remote work, it may hinder or benefit a work-life balance harmful depending on the working hours arrangement, flexibility, the clarity between personal and professional commitments and responsibilities, among others.	
7. Equal Opportunities and Discrimination	Working conditions in the context of remote work	Refer to the provisions made by the organization to enable employees to perform their duties adequately. These include all aspects directly or indirectly related to work that fall under the employer's responsibility, such as access to physical and financial resources (e.g., computer, internet, furniture, and other necessary tools or infrastructure).	
	Discrimination	Physical, verbal or non-verbal conduct in working relationships, manifested directly or indirectly, based on prejudices and stereotypes regarding class, ethnicity, race, colour, sex, sexual orientation, gender identity, disability, age, marital status, family responsibilities, religious beliefs, political opinions, social class and/or other individual or group attributes, alone or in combination.	<i>Discrimination (Employment and Occupation) Convention, C111, Violence and Harassment Convention, C190, Equal Remuneration Recommendation, R090, Discrimination (Employment and Occupation) Recommendation, R111, Violence and Harassment Recommendation, R206, International Labour Organization (ILO)</i>
	Equal opportunities	Refers to the fair and unbiased access to opportunities and resources available to all workers for advancement and/or professional development, based on objective criteria, regardless of individual and/or group attributes, such as gender, age, colour, political views, religion, ethnic origin, etc. The organization should consider the specific needs of workers to promote equitable opportunities and treatment in the workplace.	
	Discrimination in the organisational context	A set of actions taken by the organisation to prevent, investigate, combat, and punish discrimination at work, as well as to promote a healthy, respectful, and ethical environment among workers with regard to discrimination and equal treatment and opportunity.	

Table 6 (continued)

Subcategory	Indicator	Definitions	References
8. Bullying in the Workplace	Descending bullying at work	Occurs when a worker is targeted by someone in a higher position within the organizational hierarchy, such as a boss, coordinator, supervisor, manager, director, or the owner of the company. It may involve abuse of power where the person in a higher position uses authority to intimidate, menace, harass, and undermine the worker in the lower hierarchy.	<i>Violence and Harassment Convention</i> , C190, <i>Violence and Harassment Recommendation</i> , R206, (ILO), (Freitas 2007; Heloani 2004; Hirigoyen 2002, 2008; Soboll 2008)
	Ascending and horizontal bullying at work	Bullying that occurs either between co-workers, where both are at the same hierarchical level, or from a worker in a lower level of power or hierarchy towards another in a higher level. In the last case, it may involve the misuse of confidential information to coerce the supervisor.	
	Bullying at work in the organizational context	A set of actions taken by the organisation to prevent, investigate, combat, and punish bullying at work, as well as to promote an environment of respect, inclusion, and empowerment of workers.	
9. Social Security and Social Benefits	Access to social security	Access to rights related to social security, through participation in a mandatory social insurance program, aimed at replacing lost income and/or granting remuneration for conditions in which the worker is prevented from performing his/her functions in order to meet social needs, or to provide protection for the physical and mental integrity of the worker in adverse working conditions.	<i>Social Security (Minimum Standards) Convention</i> , C102, <i>Medical Care Recommendation</i> , R069, <i>Medical Care and Sickness Benefits Convention</i> , C130, <i>Medical Care and Sickness Benefits Recommendation</i> , R134, <i>Invalidity, Old-Age and Survivors' Benefits Convention</i> , C128, <i>Invalidity, Old-Age and Survivors' Benefits Recommendation</i> , R131, <i>Employment Injury Benefits Convention</i> , C121, <i>Employment Injury Benefits Recommendation</i> , R121, <i>Employment Promotion and Protection against Unemployment Convention</i> , C168, <i>Employment Promotion and Protection against Unemployment Recommendation</i> , R176, <i>Equality of Treatment (Social Security) Convention</i> , C118, <i>Maintenance of Social Security Rights Convention</i> , C157.
	Access to social benefits	Access to incentives, bonuses, assistance, and benefits in general, voluntarily provided by the employer, directly or indirectly related to the work performed by the worker, which may be paid in kind and/or through the concession of services.	

Table 6 (continued)

Subcategory	Indicator	Definitions	References
10. Health and Safety	Training in health and safety at work	Capacity building and training of actions and measures focusing on health and safety at work. Training encompasses the proper use of tools and machinery, safety equipment, and procedures for carrying out the work, provided or offered by the work organisation. It must take place continuously and be integrated with the other work procedures.	Occupational Safety and Health Convention, C155, Promotional Framework for Occupational Safety and Health Convention, C187, Occupational Health Services Convention, C161, Occupational Safety and Health Recommendation, R164, Occupational Health Services Recommendation, R171, Promotional Framework for Occupational Safety and Health Recommendation, R197, Protection of Workers' Health Recommendation, R097, International Labour Organization (ILO)
	Risk prevention and protection from work-related accidents	A set of actions and procedures adopted by the organisation to prevent work-related accidents and illnesses and protect the workers. It covers the supervision, inspection, and monitoring of the workplace and working conditions, compliance with safety rules, and protection of both the organisation and the workers.	
	Organisational policy and adherence to country laws	Refers to the existence of a health and safety policy at work, or a set of rules and procedures formalised by the work organization in documents. Both the policy and documents must be accessible to workers, allow them to participate in their drafting and review, and should comply with the country's laws.	
	Promotion of health and safety at work	A set of actions and initiatives originating from the work organisation and introduced to ensure workers' compliance with them. They aim to provide training and first aid in situations of illness, accidents, and emergencies in the work context.	
11. Sexual Harassment	Working conditions in the context of health and safety	Conditions established by the work organisation about the ergonomic characteristics of the activity, workload, division of labour, available human and material resources, and aspects related to the physical space, taking into account the adaptation of work to man, and of man to work.	<i>Discrimination (Employment and Occupation) Convention</i> , C111, <i>Violence and Harassment Convention</i> , C190, <i>Violence and Harassment Recommendation</i> , R206, International Labour Organization (ILO)
	Sexual harassment manifestations at work	Unwanted or undesirable behaviour of a sexual motive or connotation that may be expressed by words, gestures, or physical actions. Such conduct occurs in the workplace or a working context, and the approach is perceived as offensive or inappropriate by the offended person. It may involve a <i>quid pro quo</i> approach, in which the offender offers benefits or threatens the offended with a sexual favour, and/or creates a hostile and uncomfortable environment for the victim.	
	Sexual harassment in the organizational context	A set of actions taken by the organisation to prevent, investigate, combat, and punish sexual harassment at work, as well as to promote a healthy, respectful, and ethical environment among workers.	
12. Employment Relationship	Formal employment relationship	Worker who provides services and performs functions to the employer and/or organization, public or private, characterized by not having any responsibility for the business, its management, and, subsequently, has no participation in the (un)success of the initiative in financial terms. The employee receives and must follow instructions on how to carry out his/her work. The employer must provide the materials and other equipment necessary for employees to carry out their work. The employee dedicates a limited number of working hours in exchange for a fixed salary, being subordinated to whoever employs and/or assigns the work. When work is outsourced, the employment relationship is transferred to the person who subcontracts the employee's services.	<i>Employment Policy</i> , C122, <i>Employment Relationship Recommendation</i> , R198, International Labour Organization (ILO) <i>Convention</i>
	Self-employed - formal relationship	Self-employed people who have autonomy to manage their own work, acting on their own, without an employment relationship with others or with an organisation. They exercise control and are responsible for managing their own work, participating in the financial success/failure of their work or their enterprise. They may work unlimited hours, have a flexible timetable, and work in different locations.	
	Self-employed - informal relationship	Worker who either owns a company or is employed by an organisation, providing services without any type of formal arrangement, such as an employment agreement or contract. They do not usually know how many hours they will need to work in any given month, nor do they know how much their monthly pay will be due to the unpredictability of the work. The work is usually required on an irregular basis and is not planned beforehand.	

Table 6 (continued)

Subcategory	Indicator	Definitions	References
13. Working Relationship	Cooperation	Confluence and harmonisation of the practical intelligence of the individuals involved in the work, from the rules of trade to coexistence at work. Cooperation is understood to be the existence of common objectives, the union of efforts and the capacities of workers involving joint actions that promote the common good, based on joint development in the execution of the work, the fair sharing of results, and the solidarity responsibility.	Dejours 1993, 2011, 2012; Lancman 2011; Lancman and Uchida 2003
	Vertical and institutional relationships	The relationships and interaction among workers with their supervisors, in combination with the organizational formal rules, managerial practices, resources availability, workload, (lack) flexibility, (un)reasonable deadlines, (un) clear definition of tasks and roles, etc. can create a supportive or degrading working environment that may either enable or obstruct the effective performance of work tasks. More importantly, such interactions may affect workers in beneficial or detrimental ways, potentially compromising their well-being.	
	Autonomy at work	It involves the flexibility, permission, or support from the work organization for workers to use their knowledge, experience, and ability to adapt, decide, and act upon real-life and practical challenges while working. It includes creating strategies to overcome the constraints, the ability to adjust and create personalized practices to navigate them, complete tasks, and achieve goals in ways not strictly defined by formal rules or procedures of the work organization, while also not violating them.	
14. Recognition at Work	Interpersonal recognition	The acknowledgment and appreciation expressed by co-workers or supervisors for the commitment, effort, ability, competence, or “savoir-faire” of another worker. It involves social judgments of utility or aesthetic value and reinforces a sense of belonging, purpose, and visibility within the work organization.	Clot 2010; Dejours 2012.
	Intrapersonal recognition	Relates to the worker's self-perception and internal validation of his/her own value, based on their personal efforts and contributions to the work organization. Although it is self-assigned, it passes through interpersonal recognition, being affected by it, directly or indirectly, varying from person to person. It is a self-judgment that sustains identity, sense of worth, motivation, and resilience.	

Table 7 Excerpt from the scale risk prevention and protection from work-related accidents

The organisation provides protective and safety equipment to be used at work, if necessary.
The organisation promotes concrete actions to minimize risks to workers' health and safety.
The organisation supervises compliance with the rules for risk prevention and worker protection.
The organisation requires workers to comply with all the rules relating to the prevention of risks and the protection of their health at work.
The organisation monitors access to dangerous substances.

used for elaborating the indicators and their respective items is provided in Table 6.

As previously mentioned, each item measures a specific aspect relating to its corresponding indicator, and together, the set of items aims to provide a comprehensive assessment of the most relevant aspects of the targeted social phenomenon. For instance, the indicator “risk prevention and protection from work-related accidents” comprises 13 items in its short form, each addressing a key component essential to evaluating this indicator. As noted in Table 7, the first item assesses whether the work organisation provides protective and safety equipment, when required, while the last item checks if the organisation monitors access to hazardous substances. For illustrative purposes, the items of this scale are rated on a five-point Likert scale, ranging from 1 (*totally disagree*) to 5 (*totally agree*). The complete version, including detailed instructions and the response scale, is provided in Supplementary Material 1.

Usually, S-LCA case studies assess each aspect addressed in each item as a single indicator, resulting in a proliferation of indicators, with different units, data collection methods, and calculation approaches, often while examining the same construct. In contrast, the present approach assumes that a single construct should comprise a single indicator, encompassing its various dimensions, all measured using a consistent unit and data collection method. This ensures greater scientific coherence, facilitating data collection, comparisons between different studies, and aggregation of the results expressed in the same unit.

As observed in Table 8, the items' exclusion was not equal throughout the indicators of each scale. The item's exclusion varied significantly throughout the instruments, having no reduction in some cases, e.g., working conditions in the context of health and safety, or being greatly reduced, such as the case of the Forced Labour scale. Nevertheless, the exclusion of all items was made without compromising the coverage of the social aspects and topics that are core for assessing every respective phenomenon.

The network analysis showed that for some indicators, there were items represented sparsely in the network graph, showing a small closeness, i.e., distance from other items

assessing the same indicator, indicating a potential assessment of other indirect aspects related to this indicator. Other possibilities related to a low betweenness or strength, representing a lower connection and strength with the other items assessing the same indicator.

Whenever the items showed a small closeness or low betweenness and strength, and also indicated a low loading factor and, on top of that, the content of the item was not empirically essential for assessing the indicator, or the content was already covered by another item, then it was excluded. This thorough process of analysing the items' performance from several angles explains why some indicators had a greater reduction than others.

4 Discussion

The definition of decent work goes far beyond a concept and certainly aims to achieve more than endorsing international standards for regulating and promoting labour in the working market. The idea of decent work, established by the ILO in 1999, embodies a long-standing desire to promote a sustainable and dignified life for all. Dignity, naturally, lies in the creation of productive, quality jobs for men and women, the expansion of social protection and equal opportunities for all, in conditions of freedom, equity, and security. In this way, decent work converges on four of the ILO's strategic objectives: employment, the promotion of fundamental rights at work, social protection, and social dialogue (ILO, 1999).

According to Abramo (2015), the desire for a decent life predates the notion of decent work, being on the civilising agenda at the end of the 19th century with the firing of the trade union movements at international level, which coincides with the formulation of labour legislation in various parts of the world, as well as the establishment of the ILO itself in 1919. Since then, much has improved, but the integral promotion of decent labour is still an ongoing effort for developed and developing economies.

With this in mind, this work was proposed as a way of facilitating the collection of primary data relating to the sub-categories of the 'worker's stakeholder, in a reliable manner. Moreover, it sought to be exhaustive in terms of the most relevant themes for promoting decent work, providing sub-categories not yet foreseen in the S-LCA Guidelines (UNEP, 2020), such as bullying in the workplace, working relationships, recognition at work, and remote work. The first three themes have been the subject of decades of construction and discussion in sociology, psychology, and anthropology, and are undeniably important given the link between degrading and harassing working conditions or a lack of recognition at work with a drop in productivity (Karasek and Theorell

Table 8 List of all scales with the number of items in the long and short versions

Subcategory	Indicator	Number of items	Number of items
		Long version	Short version
1. Forced Labour	Involuntary nature and maintenance of forced labour	23	13
2. Child Labour	Light work	6	5
	Hazardous work	7	5
	The worst forms of child labour	10	7
3. Freedom of Association and Collective Bargaining	Trade unionism	8	5
	Collective bargaining	9	5
4. Fair Salary	Living wage	9	7
	Equal pay	6	3
	Equitable salary	5	3
5. Working Hours	Workday flexibility	8	4
	Paid rest	4	4
	Working hours regulation	3	3
	Overtime	7	4
6. Remote Work	Remote workday	9	4
	Work-life balance	9	7
	Working conditions in the context of remote work	10	6
7. Equal Opportunities and Discrimination	Discrimination	11	4
	Equal opportunities	11	8
	Discrimination in the organisational context	10	8
8. Bullying in the Workplace	Descending bullying at work	10	6
	Ascending and horizontal bullying at work	8	6
	Bullying at work in the organizational context	9	7
9. Social Security and Social Benefits	Access to social security	11	8
	Access to social benefits	8	4
10. Health and Safety	Training in health and safety at work	10	10
	Risk prevention and Protection from work-related accidents	14	13
	Organisational policy and adherence to country laws	13	13
	Promotion of health and safety at work	11	8
	Working conditions in the context of health and safety	10	10
11. Sexual Harassment	Sexual harassment manifestations at work	19	13
	Sexual harassment in the organizational context	9	9
12. Employment Relationship	Formal employment relationship	5	3
	Self-employed - formal relationship	3	3
	Self-employed - informal relationship	5	3
13. Working Relationship	Cooperation	6	5
	Vertical and institutional relationships	18	12
	Working autonomy	5	3
14. Recognition at Work	Interpersonal recognition	7	5
	Intrapersonal recognition	5	5

1990), absenteeism (Elovainio et al. 2002; Zhang et al. 2017), depression (Stansfeld and Candy 2006; Theorell et al. 2015), cardiovascular problems (Kivimäki and Steptoe 2018), and even suicide (Luo et al. 2023). Remote work, on the other hand, has gained ground since the Covid-19 pandemic, standing out from its original subcategory (Working Hours) outlined by the ILO (ILO, 2021a), gaining its own scale for assessing the different aspects, positive or negative, that it can encompass.

Since the long versions presented “good” to “excellent” validity indices for both content and based on the internal structure of the scales, as well as “good” to “excellent” indices of reliability for each instrument’s indicators (Chabrawi et al. 2024), a short version was developed for each tool. After conducting the stepwise approach for items removal, the re-application of the reduced instruments, the CFA showed excellent results once again for the indices of goodness-of-fit and reliability. The reduced instruments are

applicable in cases where all kinds of working conditions and/or investigational constraints are not conducive to the use of the long version, while bringing greater agility and being less time-consuming.

Given that all the scales were built together at the same time, it was possible to monitor and avoid cases where scales with similar measures contained similar items and, directly or indirectly, assessed the same phenomenon. Therefore, extreme care was taken to avoid double-counting, i.e., considering the same information more than once in the data collection procedures. This may be an issue, as double-counting the data, whether positive or negative, would also inflate the social impact assessment. Each subcategory is assessed by one or more indicators, and each indicator is measured through multiple dimensions within its respective domain, offering a rigorous assessment and a comprehensive representation of the underlying reality. In this sense, each indicator holds a wide coverage of the measured phenomenon, once it is comprised of several items, and each item measures a different dimension of the indicator.

In Sect. 4.1 to 4.3, general and specific guidelines for applying the scales are provided. This is followed by recommendations for impact assessment, aggregation and weighting, using the results yielded from the instruments. Finally, potential limitations are presented and discussed.

4.1 Application in S-LCA case studies

General recommendations regarding the purpose of use, application, and how to generate the instrument scores were provided in the work of Chabrawi et al. (2024, p. 14). Further recommendations and best practices are highlighted here.

All scales were designed as a self-report measure, which means that they are responded by the workers themselves, except the Child Labour and Forced Labour ones, that are a hetero-report measures, i.e., they are responded or reported by someone else other than the workers in condition of forced and child labour. These may be the local community, other workers from the same organization, etc. They were designed as such because of the possible difficulties of reaching out to these workers due to their illegal status of work. Also, all scales are suitable for application in both developed and developing countries, given their alignment with the International Labour Organization (ILO) standards.

The instruments may be applied to workers in any economic sector, position, hierarchical level, provided that are above 18 years of age. During the process of developing the long version of the instruments, special care was given to semantics and content coverage. To this end, various types of focus groups were conducted, involving workers coming from different economic segments and positions, in order

to: (1) Map intricacies corresponding to different types of work; (2) Examine pertinence, relevance importance and clarity of each item with groups of S-LCA experts; and (3) Validate the semantics with the target population, identifying and eliminating potential bias, distortive interpretations or overly complex jargon, enhancing clarity and ease of understanding (Chabrawi et al. 2024).

Depending on the work context, some of the topics addressed by the scales may be sensitive, such as those involving interpersonal relations, organizational practices, or workplace well-being. For this reason, all instruments were primarily designed for use in survey-based applications, in a fully confidential and non-traceable manner, ensuring respondents' anonymity and promoting honest and reliable responses. This approach follows ILO recommendations for collecting data on sensitive work-related issues while safeguarding workers' privacy and psychological and employability safety. S-LCA practitioners or researchers from other disciplines may complement these scales with a sociodemographic questionnaire (e.g., position, age, gender, etc.) to enrich the interpretation of the results. However, caution is advised when administering such additional questions in small group of workers, as they might fear potential traceability and, consequently, provide fewer genuine responses. Likewise, the instruments are suitable for collecting data from workers at any stage of an S-LCA, as online surveys can facilitate primary data acquisition throughout the supply chain.

It is recommended that in cases where the target population is partially or fully illiterate, some possible resources can be used for data collection, namely: (1) identify someone the workers and/or the community trust (depending on the scope of the research), and train he/she in the application of the scale(s); or (2) use the items from the scales as a structured or semi-structured questionnaires to be used in interviews with workers. In addition to collecting primary data, the results generated from the scales can also be used to identify potential issues of greater criticality for research prioritisation, as well as to triangulate data obtained from other sources of information, whether primary or secondary.

Every instrument contains instructions that briefly explain the construct and how to respond to the them. It is important to mention that the instructions were also subject to understanding and clarity checks during the semantic analysis focus groups, as well as in pilot testing of the instruments (Chabrawi et al. 2024). All questionnaires comprise a 5-point Likert scale, being either expressed in terms of level of agreement that the respondent has (1 - "totally disagree" to 5- "totally agree") or frequency (1 - "never" to 5 - "always"). A "not applicable" (N/A) option is also offered to respondents, as in some working contexts, one or more items may not be deemed applicable for the assessment.

It is estimated that each instrument would take from 5 to 10 min to be completed, depending on each individual, and the number of items, as it varies according to the subcategory assessed.

The reduced version of the instruments is provided in the Supplementary Materials in two documents: (1) Final format ready for application, with instructions to respondents (Supplementary Material 1); (2) Items of each scale, separate by their corresponding indicator (Supplementary Material 2), to support practitioners in calculating the scores of each indicator. The name of each indicator is removed from the application format to avoid biasing workers when responding. It is important to mention that the items of each scale should be applied in the exact same order as presented in the final format. Research in psychometrics has shown that item sequence can influence how respondents interpret and answer them (Schwarz 1999), as a different order may trigger other cognitive processes and affect the comparability of responses.

Finally, specific interpretation of the results or practical guidance on applying each instrument are provided in the next subtopics, according to each impact subcategory.

4.1.1 Forced labour

The Forced Labour instrument aims at verifying the occurrence of the most typical situations in which a person is subjected, while being coerced to work through different means under forced labour conditions. The items encompass a wide range of situations of forced labour – from its inception to its maintenance, as well as the various characteristics from the typologies in which they manifest themselves, as established by the ILO (1930a), namely: debt bondage, human trafficking, and slavery. In this way, higher scores will indicate a greater coverage of the types and the frequency of forced labour.

The statistical analyses indicated only one indicator for this instrument, due to the similarities in the working conditions shared among the three typologies (debt bondage, trafficking in persons, and slavery). They may differ in relation to the original route that leads workers into them, and on the maintenance strategies to keep them in these conditions, but the establishment of deception, violence, and threats are markedly common traits. Other strategies, such as retention of documents that are typically relatable to human trafficking, can also be found in slavery and debt bondage. Likewise, maintaining workers in debt is also present in trafficking in person conditions, making it difficult to set up a clear threshold among them.

4.1.2 Child labour

The Child Labour scale aimed to identify and diagnose the occurrence and typologies of child labour across diverse contexts in which it may manifest. Importantly, not all types of child labour are illegal. The Child Labour instrument encompasses three indicators: 1. Light work; Hazardous work; and 3. Worst forms of child labour. When all criteria specified in its definition are met (see Table 6), light work is lawful, and may constitute a pathway for capacity building and socioeconomic inclusion. By making a clear distinction between legal and illegal forms of child labour, as well as between the conditions to which children are subjected, the instrument enables a clear and unambiguous assessment of the forms of child labour that should be categorically combated. Consequently, in communities where children engage under lawful and regulated conditions for diverse socioeconomic reasons, livelihoods would not be inadvertently disrupted by a “blind” negative assessment resulting from an S-LCA study. Similarly, the scale differentiates hazardous work from the worst forms of child labour, duly illustrating the intricacies and complexities of each condition through the items.

The Child Labour scale is a hetero-report measure to facilitate the investigation and diagnosis of the occurrence of child labour, given that initiatives to monitor illegal child labour are not always able to detect and access children directly. Similarly, the scale was not elaborated as a self-report because children under these conditions are often illiterate and unaware of the illegal conditions in which they work. Therefore, it is expected that this instrument may not only support in assessing child labour, but also maximise the reach of the most diverse situations in which it occurs, whether they are masked or not. Thus, the Child Labour scale can be widely used and applied, both in urban and rural labour contexts, to people directly or indirectly related to the labour context under investigation.

4.1.3 Freedom of association and collective bargaining

The purpose of this scale was to develop a measurement instrument capable of investigating the situations in which workers may or may not exercise their right to join unions or associations, as well as to engage in collective bargaining. Both contexts aim to guarantee workers the mechanisms to unite and create improvements in working conditions, being an important tool for engaging workers with employers to promote a reduction in social and economic inequalities (Internationales Arbeitsamt & International Labour Conference, 2008).

Currently, the world faces a globalised labour market with a steady decline in union membership (Frege and Kelly

2003; Visser 2019). It is therefore recommended to use this instrument not only in the context of the S-LCA, but also in other work situations where guaranteeing workers' fundamental rights may be at risk or fully violated. Moreover, this scale may be applied in association with the employment relationship instrument to verify the nature of the worker's link to the organization. Comparing the rights foreseeing in the given employment relationship to the results of the freedom of association and collective bargaining scale can provide insightful findings on how and the extent to which the work organization is granting or forsaking.

4.1.4 Fair salary

The purpose of the Fair Salary scale was to capture the complexity embedded in the combined notion of the terms "fair" and "salary". According to Oelz et al. (2013), salary can be conceptualised based on the three interrelated dimensions: living wage, equal pay, and equitable remuneration. Regarding equal pay, it is important to highlight that while it is commonly associated with the gender pay gap between men and women, it should be understood more broadly, including all individual differences that may lead to wage disparities, provided they occupy equal positions or perform similar functions under the same conditions. The Fair salary scale can be used in a wide range of work contexts where there is an exchange between services rendered and monetary compensation. In many contexts, work arrangements are highly precarious, and underpayment is often justified as a strategy to retain employment, framed as an alternative to unemployment and poverty (Antunes and Pochmann 2007).

Beyond merely diagnosing cases where workers' wages are fully or partially unfair, it is essential to identify underlying mechanisms that produce and sustain wage-related injustices, commonly manifested through unequal or inadequate payments, in order to enable appropriately redress and accountability measures. The Fair Salary scale may yield particularly relevant insights when applied in combination with the Working Hours, Employment Relationship, and Freedom of Association and Collective Bargaining. Fair salary outcomes can be directly link to the amount and conditions of working hours, including situations in which overtime is performed, but not rendering a living wage, for instance. Likewise, results related to employment relationship and freedom of association and collective bargaining, when analysed alongside fair salary assessments, provide important evidence regarding the respect for and fulfilment of labour rights, such as the right to bargain for better salaries or having a fixed regular payment, depending on the nature of the employment relationship.

4.1.5 Working hours

The Working Hours scale was developed to assess working time arrangements, including working hours, paid rest, workday flexibility and overtime. Rights such as weekly rest periods and paid vacation were secured after decades of labour struggles worldwide; however, many workers still do not effectively these rights. In contemporary labour markets, workers may operate at the margins of practices of false self-employment, gig economy exploitation, "uberisation", in which individuals are hired as independent legal entities to circumvent standard labour protections, or are engaged in fully informal arrangements (Pochmann 2019). Under such conditions, workers frequently exceed daily and weekly working time limits without receiving any form of overtime compensation.

The Working Hours instrument can be used in a wide range of contexts beyond its original purpose within S-LCA studies. It may support labour inspections, serve as a complementary input to psychological assessments, such as burnout diagnoses, and assist human resources departments in identifying actual working practices within organisations, among others. Due to the intrinsic connection to labour contracts and agreements, applying this scale in combination to the Employment Relationships instrument may reveal important findings about the formal or informal nature of the working link, and potential inconsistencies with legally or contractually prescribed working time regime.

4.1.6 Remote work

The Remote Working scale was developed to assess key dimensions of remote work arrangements that may have both positive and negative implications for workers' professional and personal lives. In line with the ILO definition, remote work refers to work performed partially or entirely outside the standard organisational setting (ILO, 2021b). While previous research has highlighted benefits such as flexibility, autonomy, and improved work-life balance (Messenger et al., 2017), post-pandemic evidence also indicates that inadequate remote working conditions are associated with longer working hours, difficulties in disconnecting, poor ergonomic conditions, and blurred boundaries between work and personal life (ILO, 2021a).

The Remote Work scale was built to reflect these risks and benefits, emphasising the role of organisations in ensuring adequate working conditions, workload management, provision of equipment, and respect for the right to disconnect (ILO, 2021b, 2022). Accordingly, the scale supports the monitoring and assessment of remote working conditions across different contexts and hierarchical levels, contributing to the identification and prioritisation of critical issues.

While it does not replace in-person ergonomic assessments, the instrument provides a pragmatic tool to detect problematic remote work arrangements and inform corrective and preventive actions, in line with workers' rights and social protection standards (ILO, 1996).

4.1.7 Equal opportunities and discrimination

The Equal Opportunities and Discrimination scale was developed to assess the presence or absence of discriminatory practices and the promotion of equal opportunities in the workplace. While the scale directly addresses the S-LCA context, its applicability extends beyond it. The instrument may also be used as a semi-structured tool to support interviews on discrimination in work settings, as well as for human resources purposes, enabling organisations to identify, monitor, and address discriminatory practices and violations of equal opportunities. In addition, the scale may support the design, implementation, or revision of public policies aimed at understanding, preventing, and combating discrimination at work.

Discrimination in the workplace is often interlinked with violations of other labour rights, including the right to a safe and healthy working environment and the right to dignity and respect at work (ILO, 2019a). Accordingly, applying the Bullying in the Workplace, Working Relationships, and Recognition at Work scales in combination is recommended to obtain a more comprehensive assessment of working conditions and to better capture the types and severity of rights infringements to which workers may be subjected.

4.1.8 Social security and social benefits

The Social Security and Social Benefits scale assesses the protection of the fundamental right to social security and access to internationally recognised social benefits within work organisations. While eligibility criteria vary across national systems, the scale provides a standardised means to verify whether such benefits are effectively granted to workers. Access to social security is central to workers' protection and is closely linked to the realisation of other fundamental rights. However, in many contexts characterised by precarious employment and flexible contracting models, workers are excluded from social security coverage, despite narratives of autonomy and entrepreneurship (Pochmann 2019). In such conditions, the absence of social protection exacerbates vulnerability and undermines social justice.

Beyond its application in S-LCA studies, this scale can support labour inspections, union negotiations, and organisational decision-making. Its combined use with the Employment Relationship scale is recommended, as it enables a clearer identification of employment arrangements

and strengthens the interpretation of labour conditions and rights fulfilment.

4.1.9 Health and safety

The Health and Safety scales comprise five independent instruments covering key indicators related to this impact subcategory (see Table 6). Together, they reflect core international labour conventions and ILO Occupational Safety and Health Management Systems guidance, addressing long-standing concerns related to safe and healthy working conditions. It is important to note that these scales were designed to assess inventory indicators, focusing on aspects related to the promotion of health and safety and the prevention of occupational risks and accidents. Consequently, indicators commonly assessed in S-LCA, such as the number of fatal or non-fatal accidents, were interpreted as impact indicators and were therefore intentionally excluded from the item sets.

Despite extensive international standards and national legislation, recent data point to a critical global situation. In 2019, over 395 million workers reported non-fatal occupational injuries, and nearly 3 million deaths were attributed to work-related causes, the majority of which were linked to occupational diseases (ILO, 2023). Unsafe working conditions also generate substantial economic costs, with occupational accidents and diseases estimated to account for a 5.4% loss in global GDP (ILO, 2022a). Accordingly, assessing compliance with health and safety requirements remains an ongoing responsibility for organisations across sectors. Depending on the nature of work performed, not all instruments may be applicable, and researchers should therefore select the most appropriate scale or combination of scales for the specific study context, particularly in service-oriented settings.

4.1.10 Sexual harassment

The Sexual Harassment scale assesses the behavioural manifestations of sexual harassment in the workplace, understood as any unwanted conduct of a sexual nature. Despite cultural and contextual variations in how sexual harassment is defined and experienced, the items of this instrument were designed to capture both the occurrence and frequency of behaviours commonly associated with sexual harassment at work. In addition, an independent organisational subscale was developed to assess the extent to which organisations identify, investigate, and address sexual harassment. The main scale uses a frequency-based response format, ranging from 1 (never) to 5 (always), while the organisational subscale employs an agreement-based response system, ranging from 1 (totally disagree) to 5 (fully agree).

As the instrument is self-reported, responses capture only experiences personally lived by the respondent, rather than observations of harassment directed at others. This design choice reflects the subjective nature of sexual harassment, which requires the individual to perceive the conduct as offensive, harmful, or unwanted (McCann 2005; ILO, 2019a). The ILO (2018) identifies sexual harassment as one of the most prevalent psychosocial risks at work, associated with outcomes such as depression, stress, insomnia, and hypertension, which in turn affect performance and productivity.

Given the embarrassment, fear, and discomfort often associated with both experiencing and reporting sexual harassment, the availability of a confidential and robust assessment instrument is essential. From an organisational perspective, sexual harassment is associated with significant negative consequences, including legal actions, increased turnover, absenteeism, productivity losses, and reputational damage (McCann 2005). Identifying, investigating, and sanctioning sexual harassment is therefore central not only to protecting workers' dignity, but also to fostering respectful work environments and promoting organisational well-being and productivity.

4.1.11 Employment relationship

The Employment Relationship scale was designed to identify and categorise workers' employment relationships based on work characteristics, obligations, and the existence of an employment link. As employment definitions vary across countries, the absence of a formal employment relationship often results in informality, rendering workers invisible and excluding them from fundamental labour rights, such as social security.

The scale comprises three indicators: formal employee relationship; self-employed with a formal relationship; and self-employed with an informal relationship. The latter two capture forms of self-employment characterised by subordination without corresponding labour protections, including disguised employment. This is particularly relevant in the context of the gig or on-demand economy, where workers are classified as independent contractors despite close supervision and extensive obligations, while lacking access to labour law protections and collective rights (ILO, 2016a; b).

Given the strong links between employment status, precariousness, and access to labour rights (Lancman 2011), assessing employment relationships is essential to clarify discrepancies between workers' duties and the rights they effectively receive. Accordingly, this scale is best applied in combination with other instruments, such as Social Security and Social Benefits, Fair Salary, and Freedom of

Association and Collective Bargaining. It is noteworthy that the results of this scale should not be used conclusively. It is necessary to compare it to how the worker has self-assigned his employment relationship against the scores obtained for each indicator, in order to identify the extent to which the responses align with each category. Moreover, the results can be used for triangulating the information provided by work organizations, helping to detect possible discrepancies in the prerogatives determined by law concerning the rights and duties of both parties.

4.1.12 Bullying in the workplace

The Bullying in the Workplace scale assesses perceptions of workplace bullying within power relations, focusing on observable behavioural manifestations, including verbal, non-verbal, and physical abusive conduct. Bullying is understood as repeated or systematic behaviour that undermines workers' dignity or psychological or physical integrity and degrades the work environment (Hirigoyen 2008; Barreto 2003). This conceptualisation is aligned with ILO Convention No. 190, which defines violence and harassment in the world of work as unacceptable behaviours that result in, or are likely to result in, physical, psychological, sexual, or economic harm (ILO, 2019a).

Bullying may occur in vertical or horizontal forms, reflecting power asymmetries within organisations, and may also be embedded in managerial practices and organisational structures aimed at control and performance intensification (Hirigoyen 2002; Soboll 2008). Accordingly, the items of this scale assess inventory indicators related to explicit and observable abusive behaviours at work, as defined in the literature and ILO standards. Psychological and physical consequences of bullying were intentionally excluded, as they are considered impact indicators. Although sexual harassment is addressed alongside bullying in Convention No. 190, it was intentionally excluded from this scale and analysed separately to avoid double counting within S-LCA applications.

Given the documented links between workplace bullying, stress, absenteeism, turnover, and reduced organisational performance (Di Martino and Musri 2001), this scale supports the systematic identification of abusive work practices and contributes to the promotion of respectful and healthy working environments, both within and beyond the S-LCA context.

4.1.13 Working relationships

This instrument was developed to assess working relationships within the organisational context, drawing on the Psychodynamics of Work as its theoretical and conceptual

framework. This approach enables a transversal integration of insights from psychiatry, sociology, philosophy, and psychology. Work is understood as a foundational category in human life, mediating the relationship between individuals and society and contributing to the construction of identity and social belonging (Max, 1983). For Dejours (2011), working relationships emerge from the coordinated activities of workers guided by organisational rules, norms, and prescriptions, as they confront the concrete realities and constraints of work. In this sense, labour relations may either empower and emancipate workers or, conversely, become predatory and precarious, shaping not only their position in the labour market but also their personal and social development (Lancman and Uchida 2003).

According to Dejours (2012), work is experienced through the constant tension between what is prescribed and what is real. The prescribed dimension encompasses formal rules, protocols, and procedures, while the real dimension reflects the unpredictability of work situations, including unforeseen events and the frequent inadequacy of formal instructions. The way workers navigate this gap strongly influences their experience of work, which may result in suffering or, alternatively, in well-being and pleasure. Persistent competition, isolation, and cynicism tend to generate stress and loss of meaning, whereas cooperation, trust, and solidarity foster meaningful, productive, and emancipatory work experiences.

Empirical evidence supports this framework. The ILO (2019a, 2019b) reports that working relationships characterised by violence, threats, or excessive demands are associated with absenteeism, turnover, accidents, burnout, and worker disengagement. Similarly, the ILO (2020) highlights how globalisation and intensified competition have increased workloads and working hours, amplifying psychosocial pressures. Poor work design and management practices, such as excessive workloads, role ambiguity, lack of autonomy, insufficient support, and ineffective communication, are recognised psychosocial risk factors (EU-OSHA, 2024), contributing to stress, cardiovascular disease, depression, and absenteeism (Kivimäki et al. 2012; Xu et al. 2019; Zhang et al. 2017). Globally, depression and anxiety linked to work are estimated to result in the loss of 12 billion working days annually, with productivity costs reaching US\$1 trillion (EU-OSHA, 2024).

Assessing working relationships is essential for diagnosing the quality of organisational environments and workers' well-being, particularly because this subcategory captures dimensions that extend beyond traditional health and safety frameworks, such as role clarity, autonomy, cooperation, and managerial support. Accordingly, the Working Relationships scale was designed to assess interactions across hierarchical levels and key organisational features,

including workload, coherence between tasks and instructions, flexibility in work activities, monitoring practices, competition, and the existence and application of organisational rules and procedures, enabling a structured evaluation of the relational and organisational dynamics that shape workers' experiences and well-being.

4.1.14 Recognition at work

This scale aims to identify the occurrence and forms of recognition at work, a sociopsychological process of fundamental importance for understanding job satisfaction, motivation, gratification, and pleasure at work. Its absence has been associated with suffering, illness, and depersonalisation (Dejours 1993, 2012). Recognition at work may take the form of symbolic retribution expressed through peer or hierarchical judgement of workers' abilities, knowledge, skills, and experience. Being recognised plays a central role in how workers construct meaning around their work, mediate social relationships in the workplace, and develop a sense of belonging to a collective, within which shared values and norms are formed (Dejours 2012).

Beyond its relevance for S-LCA applications, this measure may support human resources practices, enabling organisations to diagnose recognition dynamics and design targeted interventions, such as training initiatives or awareness-raising campaigns. When applied in combination with the Working Relationships scale, it supports a more comprehensive assessment of the quality of interpersonal interactions at work. Recognition constitutes a critical element of labour relations, as it can contribute either to the empowerment and emancipation of workers or, conversely, to their degradation and subjection.

Although recognition at work is not explicitly addressed in current S-LCA Guidelines under the worker stakeholder category, it has a direct impact on workers' well-being, engagement, mental health, and the realisation of decent work. These dimensions are transversal to ILO conventions and recommendations. In this regard, the joint WHO–ILO policy brief on Mental Health at Work highlights the importance of addressing psychosocial risks and stressors to foster working environments that promote well-being for all (WHO & ILO, 2022).

4.2 Impact assessment, aggregation and weighting

The scores resulting from each indicator assessment can be used both in the Reference Scale and Impact Pathways (IP) approaches. For the latter, since it requires the evidence of causality among inventory, midpoint, and endpoint indicators, as well as developing characterization factors (CF) (UNEP, 2020, ISO 14075:2024), the scores may be applied

in statistical analysis, such as multivariate regression models and Structural Equation Modelling (SEM), where the cause-effect chain can be tested and the CF developed. A forthcoming publication shall exemplify the use of SEM to develop impact pathways and CF, based on the results yielding from the several applications of the proposed instruments.

For the RS approach, a procedure known as normalisation was conducted to support potential impact assessment. In Psychometrics, normalisation refers to providing the thresholds necessary for interpreting the results from data collection. The normalized thresholds were developed, based on large samples of data (between 600 to +900 workers), using Item Response Theory (IRT), and will be addressed in a further publication. The thresholds act as a PRP and support researchers in interpreting the results, although other PRPs may also be developed based on the intricacies of each research.

Concerning aggregation and weighting, a few recommendations have been drawn up to ensure best practice when transforming the results emanating from the instruments into consistent and reliable social findings. Aggregation is a way of bringing together several pieces of information and synthesising them into a single score to facilitate understanding and communication of the S-LCA results (UNEP, 2020). While it is a common practice in business-related contexts and its importance is justified to promote a simpler decision-making process, it must meet the required scientific criteria, and not take place at any cost just for the sake of simplicity when reporting S-LCA results.

Beyond merely presenting the disaggregated data alongside the aggregated results, as indicated in the S-LCA Guidelines (UNEP, 2020) and ISO 14,075, several issues still remain to be resolved in this regard in the area of S-LCA. A few of these are related to bias (Beaulieu et al. 2014), ranging from lack of objectivity and transparency (Ekener-Petersen and Moberg 2013), to the improper use of weighting derived from materiality assessment to weight performance/potential impact, inadequacy of performing mathematical operations with ordinal data (Arvidsson 2019), among others.

Although aggregation may occur at different levels (stakeholder, impact category, and subcategory levels), the authors only recommend the aggregation of the results at the subcategory level, since the indicator(s) corresponding to each scale can be aggregated as they refer to the same phenomenon and are all expressed in the same units. As for aggregation at the stakeholder and impact category levels, it requires combining different types of phenomena (indicators). In these cases, extreme caution is recommended as synthesizing distinct social data, even when expressed by ordinal or ratio variables, they may pertain to totally

different issues that cannot be simplistically submitted to mathematical operations to represent a social impact. Social occurrences are by nature dynamic, interacting with each other, exerting different types of influence upon each other, and the outcome cannot be expressed by a mere addition or multiplication operation.

On a separate note, caution must also be maintained when dealing with ordinal scales (1, 2, 3, 4, 5, ...), such as results achieved using a Likert scale instrument. As was well put by Arvidsson (2019), the order of the values of an ordinal scale are known, but not the distance between them, which means that the position assigned as “2” cannot be regarded as double position “1”. Thus, the ordinal values cannot be subject to addition, subtraction, multiplication, since the distance between the values is not given. As also pointed by the author, in Psychometrics, there is a long-standing use of Likert scales, where data from assessment instruments is aggregated (Arvidsson 2019). However, this is only viable when a due investigation of the robustness of the procedure and the quality of the instrument is made, indicating the possibility of generating a single score from the instrument (Hongyu 2018).

Alternatively, solutions are largely found in statistics where the relationship among different types and units of variables are brought together to investigate causality, moderation, mediation, etc. Not only does this allow proving the occurrence of the cause-effect chain of impact(s), but it also displays the final outcome of the various inventory indicators as a single value, i.e., mid-point or end-point impacts, in an empirical and replicable manner.

Lastly, weighting occurs alongside aggregation in the level of inventory, impact subcategory, or stakeholder category to represent the relative importance of specific results (UNEP, 2020). When it is necessary to represent the criticality and human degradation that a social phenomenon entails by weighting the inventory results, the weights should observe good scientific practices and international norms of behaviour (ISO 14075). In addition, whether the application of weighting aims to translate the social performance or the impact, it is necessary to conduct an extensive investigation in the related literature about the consequences of the social condition under investigation, in order to create the weights in a scientifically grounded manner. This is to ensure that the numerical value is a reliable measure of the dimension of the social repercussion investigated.

4.3 Limitations of the reduced instruments

Although the short version of the instruments address the most relevant contents while covering the complexity of each phenomenon, the long versions naturally encompass a wider coverage of dimensions for assessing various other

social aspects related to the construct. In this way, whenever a more extensive assessment related to a worker-related impact subcategory is required, the use of the corresponding long version is advisable.

At the same time, the reduced versions may also apply to contexts in which not all aspects of each subcategory need to be measured, and the condensed, yet “straight to the point” version is suitable for the purpose of a given investigation. Moreover, shorter scales with good evidence of validity are also crucial for contexts in which many data are being collected, which can lead to prolonged fatigue, loss of participants. This may be the case of a social life cycle inventory, or other contexts where various aspects of working conditions are being assessed.

Because each scale is understood as an integrated measurement instrument, in which each item functions as a component of a validated structure, adding new items or questions within the scale is not advisable. Such modifications may alter the measurement properties of the instrument, disrupt the response process, generate response bias, and compromise the reliability and validity of the results (DeVellis 2017). Therefore, any additional questions or items should be administered separately from the scale, either before or after its application, but not interspersed within the scale itself, that is, within the sequence experienced by the respondent: (1) reading the instructions; and (2) reading and responding to the set of scale items.

On another note, items should not be deliberately excluded from an application, as each item exerts an effect on the overall set of items, and this may alter the measurement properties of the instrument. However, because all factors (indicators) within their respective instruments demonstrated adequate internal consistency across multiple reliability indices, and retain conceptual coherence and sufficient content coverage independently of the other factors within the same instrument, it is psychometrically acceptable to apply only the items related to a specific indicator. This is provided that the original instructions and response format of the respective instrument are fully maintained (Brown 2015; DeVellis 2017).

A limitation faced in reducing the instruments is that the application was possible only for Brazilian workers due to the ease of reaching a larger number of participants, necessary for running the statistical analyses. However, due to the great disparity of working conditions present in different Brazilian regions and economic sectors, the five large samples came from all 27 states, had a wide and heterogeneous distribution in terms of socioeconomic conditions, human development, gender, age, job position, number of industries, etc. (as per topic 3.1), the samples were considered representative and consistent proxies to workers in various working conditions throughout the world.

Lastly, despite the robust validation performed, the reduced scales may require additional testing or recalibration when applied to populations substantially different from those used in the development process. Moreover, labour regulations and normative frameworks may evolve over time, as ILO norms are periodically updated to reflect prevailing working standards. The reduced scales were not specifically designed to systematically capture such normative changes, and their sensitivity to detect subtle longitudinal shifts in working conditions has not yet been established and should therefore be addressed in future research. These limitations do not undermine the validity of the proposed instruments but rather delineate their appropriate scope of application. The reduced scales are intended as pragmatic tools for primary data collection in S-LCA, and their use may be complemented by long-form instruments or qualitative approaches where greater diagnostic depth is required.

5 Conclusion

This work sought to fill the gap of collecting primary data in a reliable and robust manner, fully based on international labour standards and norms, as well as grounded in established literature on various social sciences fields of knowledge. In addition, the work aimed at offering instruments applicable to diverse economic sectors and countries, turning comparisons across S-LCA studies possible. Furthermore, the reduction of the scales favours their application, making the data collection process faster and easier, although not always as comprehensive as the long versions, while keeping the same reliability standards.

Beyond the scope of an S-LCA case study, the instruments can also contribute to other researchers who aim to measure one or more themes related to decent work. They can be used collectively or individually, since they are independent and aim to cover different themes. In this sense, the use of the scales is not limited to specific economic sectors or company size. Beyond the scope of S-LCA studies, the instruments may also be applied in government and non-government initiatives regarding oversight, monitoring, and the combat of any practice that violates labour and human rights.

In this way, different stakeholders may use the scales, presenting it with different objectives such as: scientific investigation, production of inputs for the taking of decisions about the consumption of products and services not associated with deleterious working practices, acquisition of raw materials that will be incorporated throughout a chain of production, drafting of public policies, etc. The instruments can also be used by professionals from any field of knowledge, whether addressing the public or private

sector. Likewise, the results coming from the application of the instruments can contribute to formulating or updating public policies, programmes, and projects that envision to promote decent work, social sustainability, and human dignity in working contexts.

The long and short versions of the scales were first developed in the Brazilian Portuguese language. Therefore, a cultural adaptation, which is the translation of the instruments considering cultural aspects like semantics, cultural values, representation, etc., was already done for multiple languages. This work will be also subject of another publication. The background idea is to allow comparison between different products or services, or S-LCA stages, and facilitate aggregation, among others. Thus, as a research agenda, would be for S-LCA practitioners to apply the instruments in other countries and sectors to confirm the same structure of the instruments, goodness-of-fit, and reliability indices.

It is also important to mention that the theoretical background, methods, and results for developing all 14 instruments will be detailed in future separate publications, due to the large number of procedures and the extent of the information that need to be reported when developing a single scale. These works will also cover the full development process of the original long-form instruments to ensure transparent and comprehensive reporting in a didactic manner. Thus, detailed information will be made available, such as sample description, the individual goodness-of-fit indices to each scale, and reliability indices of each indicator, the exact items removed, etc. for both long and short versions.

With regard to impact assessment, a forthcoming work will be dedicated to providing thresholds for potential impact assessment for all instruments. These thresholds are interchangeable with the performance reference points used on the Reference Scale (RS) approach in S-LCA. The objective of this publication is to support S-LCA practitioners in assessing potential impact using standardised methods and avoid the inherent subjectivity and bias that reference scales may hold. In the same way, another publication will exemplify how SEM may act as a consistent approach for testing causality, and developing robust CF in Impact Pathways approach, using the results derived from the reduced scales.

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Declarations

Conflict of interest the authors declare that they have no financial, personal, or professional competing interests that could have influenced the research, authorship, or publication of this work.

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