A Typology of Operational Models within the Informal Waste Management and Recycling Sector

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Abstract

Purpose: Solid waste management systems in low and middle income countries typically include a multitude of actors with a wide variety of characteristics, which must be defined and understood for effective intervention. This study creates a typology of operational models observed within the informal and semi-formalised waste management and recycling sector in Latin America.

Methods: The typology was created through a systematic literature review and use of proformas to extract and cluster information from 28 case studies.

Results: Creation of a typology was challenging, due to the highly diverse nature of the informal sector and a deficit of detail within the English literature. However, a typology of 4 main activities and 10 common configurations encountered in the literature were defined and elaborated. Within the case studies examined, the majority were based on cooperative organisations and tended to employ an operational model based on providing the collection of mixed recyclables as a service. Cooperative organisations are heavily over-represented in the literature, given that they represent a minority of informal recycling and waste workers.

Conclusions: The typology presented here provides a first step in elaborating and systematising our understanding of this complex and diverse sector. It highlights the diverse roles that informal sector workers can have in waste and resource management. There is clearly a need to increase the extent of this evidence base and, given the disproportionate focus on cooperative-based activities, more focus should be given to the role of autonomous informal recyclers, who represent the greater proportion of informal workers in this sector.

Introduction

Solid waste management is an essential service which is vital to the health of urban residents, functioning of urban infrastructure, and the quality of the natural environment. In the developing world, whilst substantial progress has been made in providing waste collection and controlled disposal in the last three decades, two to three billion people remain without access to basic waste services [1]. Quantities of solid waste produced in these countries are increasing due to rising standards of living and population growth, whilst there is also simultaneous pressure to tighten environmental standards of disposal [1]. These combined factors are placing ever greater pressure on the local authorities responsible for dealing with waste.

Recycling and reusing materials are recognised as important methods to reduce the environmental impacts of waste and divert useful materials from landfill or dumping. Recycling and reuse can also support livelihoods and reduce poverty, particularly in developing countries where the majority of recycling is carried out by informal actors [2]. At present, most of these informal actors carry out their activities without any form of remuneration from the formal authorities, which can save local authorities significant sums in avoided collection costs [3]. They also often provide vital services to inaccessible or peripheral urban settlements which are otherwise unserved [4].

Solid waste management systems typically include a multitude of actors with a wide variety of characteristics [5], and the informal waste management and recycling sector (IWMRS) in particular, has a wide variety of modes of operation [6]. For instance, it includes: lone individuals operating autonomously to pick recyclable wastes from kerbside collection points or dumpsites; loose organisations or networks of recyclers; and formally registered cooperatives who may be contracted by municipalities or private companies to provide services [6, 7]. IWMRS cooperatives have received particular attention due to their potential to improve working conditions and mitigate occupational hazards that waste pickers are frequently exposed to [8–10], whilst also giving workers the power to increase their remuneration [11] and cultivate a feeling of community, personal development, and social inclusion [12, 13].

The IWMRS also includes autonomous individuals and groups (e.g. neighbourhood associations) providing waste removal services under agreement with the community, often with recycling but not always [14]. These different groups may be operating in synergy - exchanging materials in return for monetary or in-kind payments, or operating in direct competition [15, 16]. When informal organisations become legally registered and make tax and social security payments, the boundary between the informal and the formal becomes indistinct; however, in this article, we refer to formalised cooperatives of recyclers and waste workers as being part of the informal sector.

In order to initiate successful waste management programmes involving informal actors, it is necessary to understand the types of informal actors that exist, their activities and motivations, and how they operate and interact. Depending on the motivations and goals of the responsible organisation, it may be preferable to find waste management and recycling solutions which benefit a wide range of actors, or are targeted towards maximising certain social and environmental benefits. In addition, supporting organisations can benefit from understanding the different possible modes of operation for IWMRS groups, and which mode might be the most appropriate in a particular context.

To understand this further, this study creates a typology of operational models functioning within the IWMRS through a systematic literature review and analysis of case studies. The study focuses upon Latin America, a global region which is particularly notable for the high level of politicisation around informal recycling, and the tendency towards organisation and political action, with legislation and more highly structured groups emerging to support and catalyse the initiative [7, 11, 17].

Method

The method for this study involved:

- A systematic literature search in the English language for papers and grey literature relating to the IWMRS in Latin America (keywords and databases used shown in **Table 1**);
- Screening of literature for:
    - Case studies of IWMRS actors in Latin America with sufficient detail for analysis, and/or
    - General descriptions of IWMRS actor structures and characteristics which are based on original research;
- A review of selected literature to assess geographical balance, and inclusion of different types of actors;
- Development of proformas for systematic extraction of information from literature; and
- Analysis of completed proformas to identify a typology of operational models by clustering similar characteristics.

Table 1 Search terms and data bases used for informal recycling in Latin America literature review

Search Terms	Databases and Websites Searched	Results
Informal recycl* OR waste pick* OR (waste AND informal) AND	Web of Science Scopus ScienceDirect	403 abstracts retrieved from journal databases. 103 sources retrieved after removing irrelevant, duplicated, or inaccessible results.

Search Terms	Databases and Websites Searched	Results
[Individual Latin American country names] OR Latin America OR Caribbean	Websites of relevant organisations: WIEGO, GIZ, World Bank, Inter-American Development Bank Google	28 case studies extracted after screening for sufficient detail.

Literature was reviewed against a pro-forma of aspects, which includes:

- Core elements: organisational type, affiliation and management; workforce and employment characteristics; service, activities, means, and techniques; drivers and motivations; and clients and contracts.
- Supporting elements: commercial environment; policy environment; external support; regulation; and interface with SWM system.

The 28 identified case studies were analysed and results presented according a pro-forma of characteristics, the key features of which are shown in **Table 2**.

Table 2 Characteristics for analysis of case studies

Characteristics	Categories
Activity type	Waste collection service; waste collection service with recyclables diversion; recyclables collection; recyclables collection service
Type of organisation	Cooperative; group; family; loose network; individual
Premises	Owned premises; right to use premises; no premises
Income	Above national minimum wage; below national minimum wage
Contractual arrangements	Formal contract; informal contract; no contract
Relationship with authorities	Engaged with; supported; ignored; colluded; repressed
External support	Material support, monetary support, no support

Results

Literature Review Characteristics

Figure 1 shows the geographical focus of papers retrieved from the literature review, alongside the population of the countries covered. To be assigned to a particular location, the papers must provide either a comprehensive case study or detailed discussion about the particular country. This was subjective to a degree, and relied on reviewer judgement.

For the most part, the relative representation of the Latin American countries in the IWMRS literature is reasonably correlated with their relative populations. Mexico is noted to be somewhat under-represented in the literature, appearing in only 8% of papers but containing 23% of the regional population. The Caribbean is also under-represented, appearing in 3% of papers whilst containing 8% of the regional population.

Many Latin American countries had no representation in the literature at all (this includes: Paraguay, Venezuela, Guyana, Suriname, French Guiana, Panama, Costa Rica, El Salvador, Belize, and all Caribbean islands except for Cuba, St Lucia, Jamaica, and Haiti).

Figure 2 shows the types of organisational models in the IWMRS which are mentioned and discussed in the reviewed literature. To be assigned to a particular organisational model category, the reviewer judged whether papers provided either a comprehensive case study or detailed discussion about the particular organisational model.

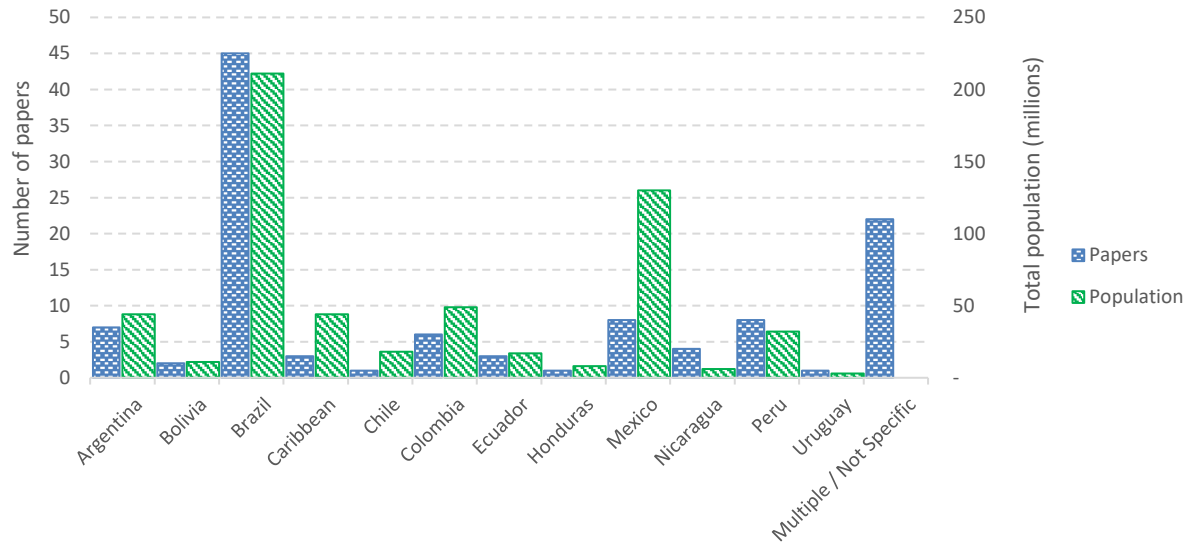


Fig. 1 Geographical focus of papers retrieved from literature review and country population; population data taken from the World Bank data base [18]

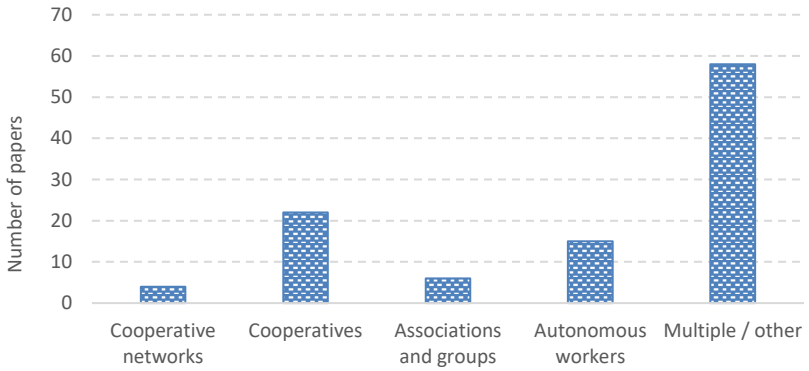


Fig. 2 Organisational models mentioned and discussed in the papers retrieved from literature review

The papers show a slight focus towards focus on cooperative models, which appeared in 22% of all reviewed papers. Papers focussing on autonomous workers make up a smaller percentage, at 15% of the total, despite making up a significantly higher number of waste pickers in reality (estimated as more than 90% of all recyclers in Brazil [15]. The majority of papers, however, opted to either discuss a variety of operational models or not focus discussion on a particular operational model – these made up 57% of all papers.

Operational Models

Workers in the informal waste management sector display great variation in their characteristics, including: the ways in which they choose to affiliate, organise, and work with others; relationships with customers and buyers; their degree of formalisation; the places in which they work; the support they receive from local authorities and other organisations; and in their equipment, income, and status. Common 'types' of waste pickers described in the literature include: autonomous individuals searching for recyclable waste in street bins or in landfill sites; itinerant buyers; or members of organised cooperatives or associations, which may also be part of a network of cooperatives.

These different formations, with all their diversity, can be narrowed down to four basic operational models, which are shown in **Table 3**.

Table 3 Basic IWMRS operational models

Primary focus is:	Type	Activities	Primary purpose is:
Removing waste	I	Waste collection service	Service provision
	II	Waste collection service Recyclables are separated	Service provision and valorisation
Collecting recyclables	III	Recyclables collected	Valorisation
	IV	Recyclables collection service Rejects are separated	Service provision and valorisation

Operational Model Type I involves provision of a waste collection service, whereby waste is collected from households (or, in some cases, construction sites or commercial/business premises) and removed. This waste may be disposed of at a sanitary landfill site or controlled dumpsite, or it may be dumped indiscriminately into the environment. This type of operational model is more frequently employed by the IWMRS in informal settlements, which might be inaccessible to municipal solid waste service providers who are unable or unwilling to navigate and enter in large trucks. The service provision therefore fills a niche, whilst providing environmental and public health benefits to residents, who are often willing to pay for it. The fee from the service, whether received directly from households or from a contracting authority, provides the revenue stream.

Operational Model Type II is identical to *Type I*, except that recyclables are diverted from the waste stream and sold to material buyers for valorisation to provide a second revenue stream. The quality of these recyclables may not be high, as they have been extracted from mixed waste.

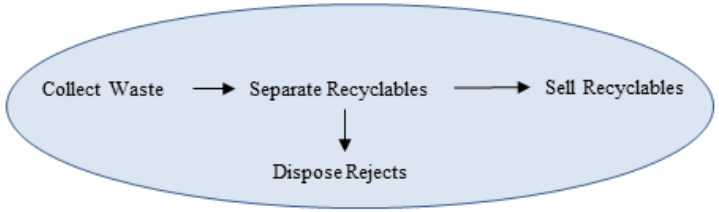
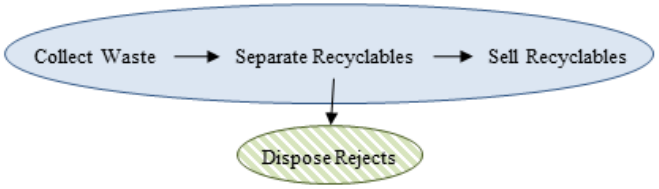
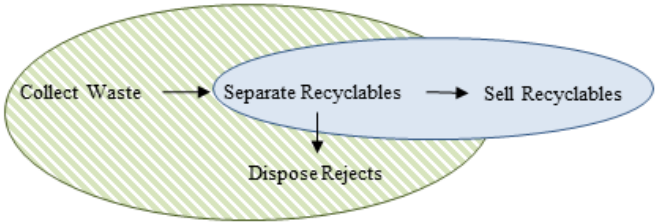
Operational Model Type III involves the collection of separate or comingled recyclable materials for sale to material buyers. Collection could occur from households, whereby recyclers might go door to door requesting materials, or from selective picking from mixed waste in bins or litter in the streets, or from mixed waste at a landfill, dumpsite or transfer station. There may be an element of processing, whereby recyclables are sorted, washed, compacted or baled prior to sale. An important element of *Type III* is the absence of any aspect of service provision; recyclers are selective in the materials that they recover.

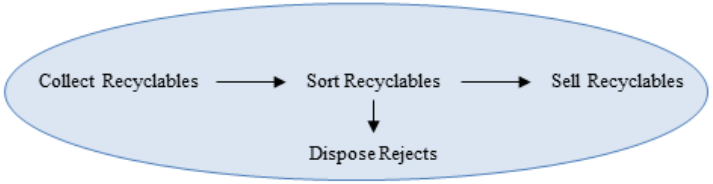
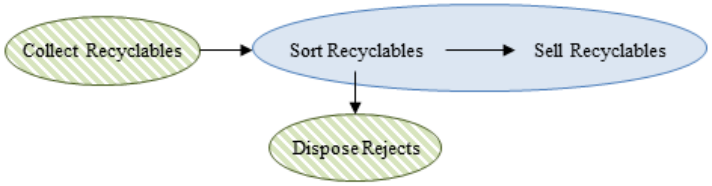
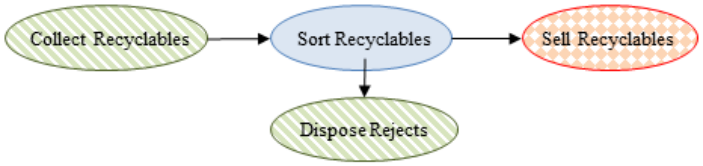
Operational Model Type IV involves the provision of a collection service of comingled recyclable materials from households, businesses/commercial premises. These materials are sorted and reject material removed, and some element of processing may occur prior to the sale of the materials. *Type IV* is distinguished from *Type III* by the element of service provision, which indicates a regular collection pattern. It also means that recyclers are less able to be selective about the materials received, which usually results in a sizable stream of reject material which must be removed and disposed of. Recyclers might receive a service fee from households or the contracting authority, or may depend solely on material sales for revenue.

These basic operational models are realised in a set of configurations whereby various actors take responsibility for the tasks of collecting waste/recyclables, sorting recyclables, and disposing of rejects/waste. The most common examples encountered in the literature are shown in **Table 4**.

In addition to the IWMRS actors, these configurations of operational models also commonly involve local authorities (LAs), and private companies. These are represented by shading in the configuration diagrams in **Table 4**. Blue / solid blocks indicate the IWMRS, green / diagonal stripes indicates the LA (or organisations contracted to carry out waste management services on their behalf), and red / chequered pattern indicates the private sector.

Table 4 Common configurations for each IWMRS operational model

Type	Configuration	Description	Example
Ia		**Waste collection service** – waste is collected directly from households and disposed (either at a landfill or open dumpsite) by the IWMRS.	Carroceiros, Belo Horizonte, Brazil, prior to intervention [19]
Ib		**Waste collection service** – waste is collected directly from households by the IWMRS and deposited at a transfer station. Waste is then collected and disposed by the LA.	Carroceiros, Belo Horizonte, Brazil [19]
IIa		**Waste collection service with recyclables diversion** – waste is collected directly from households, recyclables are separated and sold, and remaining waste is disposed (either at a landfill or open dumpsite) by the IWMRS.	Recyclers in Laredo / Nuevo Laredo, USA/Mexico [20]
IIb		**Waste collection service with recyclables diversion** – waste is collected directly from households and recyclables separated and sold by the IWMRS. Remaining waste is deposited at a transfer station, and disposed by the LA.	Micro-enterprises, Quito, Ecuador [21] Manos Unidas, Managua, Nicaragua [14]
IIc		**Waste collection service with recyclables diversion** – waste is collected directly from households by formal municipal solid waste workers. Recyclables are informally retrieved from the waste during their collection rounds, and are diverted to material buyers.	Medina and Scheinberg et al. [3, 22] discuss the separation of recyclables during municipal solid waste collection rounds

Type	Configuration	Description	Example
IIIa		**Recyclables collection** - separated recyclables are collected by the IWMRS (picking from the street, collecting directly from households, or picking from landfills), then sorted and sold.	Recyclers in Laredo / Nuevo Laredo, USA/Mexico [20]
IIIb		**Recyclables collection** - separated recyclables are collected by the IWMRS (picking from the street, collecting directly from households, or picking from landfills) and sold to another informal actor (e.g. cooperative group) who may perform further segregation and aggregation. The recyclables then may be sold directly, or sold through another IWMRS actor (e.g. cooperative network).	Coopesol Leste, Belo Horizonte, Brazil [23] Coopert, Itauna, Brazil [11]
IVa		**Recyclables collection service** – comingled recyclables are collected by the IWMRS directly from households, sorted and sold, and rejected material is disposed.	Cooperpires, Ribeirão Pires, Brazil [24, 25] Coopert, Itauna, Brazil; Cocamar, Natal, Brazil; CooperRegião, Londrina, Brazil [11]
IVb		**Recyclables collection service** – comingled recyclables are collected by the LA directly from households, delivered to the informal actor, then sorted and sold. Rejected material is collected and disposed by the LA.	Coopesol Leste, Belo Horizonte, Brazil [23]
IVc		**Recyclables collection service** - comingled recyclables are collected by the LA directly from households, delivered to the IWMRS, then sorted and sold directly to a private company, who might be a reprocessor. Rejected material is collected and disposed by the LA.	Private Company and Recyclers, La Reina, Chile [26]

It should be noted that some IWMRS actors organisations may employ multiple operational models, e.g. receiving sorted recyclables from autonomous recyclers as per *Type IIIb*, whilst also receiving comingled recyclables from the LA as per *Type IVb* – an example being the cooperative Coopesol Leste in Belo Horizonte, Brazil [23]. Naturally, multiple variations of these configurations exist, and not all of the 28 case studies identified in the literature review fit neatly into the categories.

Case Study Characteristics

Case studies were selected for analysis if they contained sufficient information and detail so as to be able to define the operational model type and configuration (as described in **Tables 3 and 4**) and complete the case study pro-forma (as shown in **Table 2**). 28 case studies that fulfilled this requirement were either identified in the literature review or known to the authors.

Key characteristics of these case studies are shown in **Figures 3-8**.

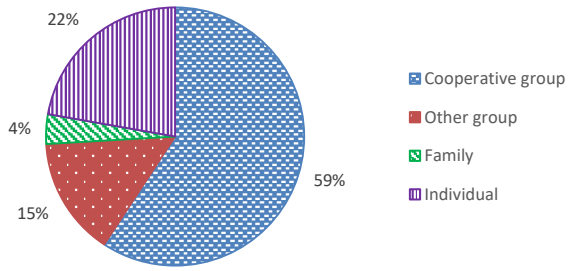


Fig. 3 Organisational type of case study groups

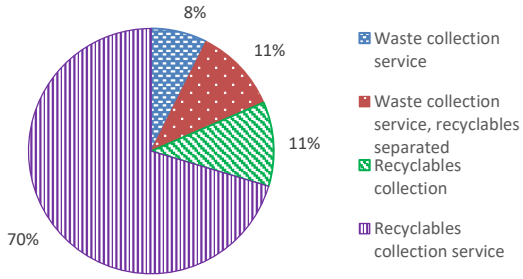


Fig. 4 Operational type employed by group (from **Table 3**)

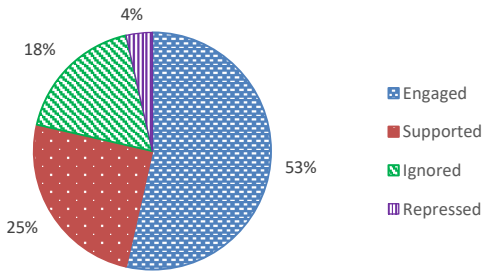


Fig. 5 Relationship with authorities for case study groups

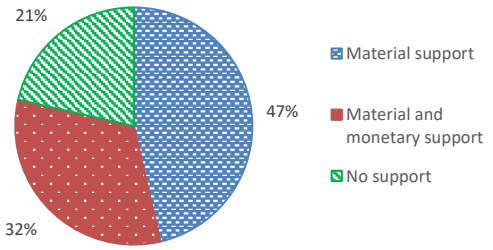


Fig. 6 External support received by case study groups

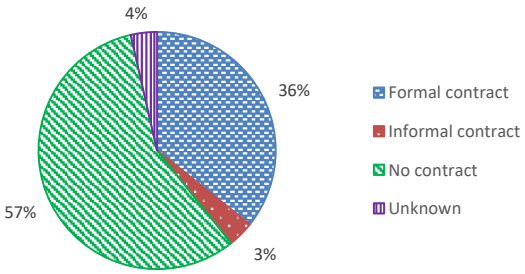


Fig. 7 Contractual arrangements for case study groups

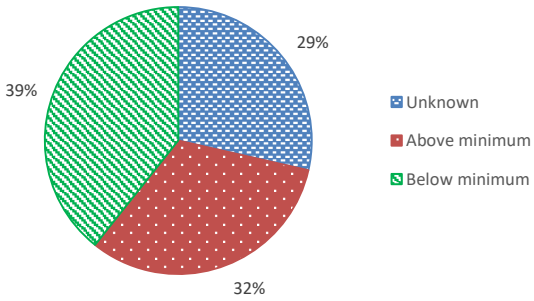


Fig. 8 Average income of case study groups in relation to national minimum wage

From **Figures 3-8** it can be seen that almost three quarters of identified IWMRS case studies contained cooperative groups who employed a recyclables collection service - a *Type IV* operational model - whereby recyclables are collected and valorised as a service to households. Over half of the case studies demonstrated local authorities actively engaging with the IWMRS groups, and over three quarters received either material or monetary support from other organisations to carry out their activities. The majority had no formal contracts to carry out their work, although over one third did have a formal contract. Approximately one third of case studies reported earnings above the national minimum wage, with the remainder either reporting earnings below the minimum wage or undefined.

Discussion

Diversity of IWMRS

Workers acting in the IWMRS are diverse in terms of activities, workforce and employment characteristics, affiliation, motivations, and contractual arrangements, in addition to operating within different commercial and political environments, with variation demonstrated along a sliding scale rather than occupying binary categories [27]. The diversity of the IWMRS can have certain beneficial aspects, such as allowing workers to tailor their activities to suit their personal situations [10] and allowing businesses to flourish where niches are found. However, detrimental aspects can include irregularities in quality and quantities of materials available to recycling industries [28] and unsteady, poorly paid employment for workers [29].

Efforts to homogenise and standardise the activities of the IWMRS (e.g. by recruiting workers into cooperatives) encounter a number of challenges. Firstly, issues around substance dependence can create barriers to steady employment [15, 10]. Secondly, the flexibility and independence of working autonomously makes this preferable to many individuals [10, 15]. Thirdly, if pay is insufficient, workers will seek out alternative employment with higher remuneration or quicker cash flow, leading to high turnover of workers and leakage of investment and skills [7, 25, 30]. Finally, if adequate managerial, financial, technical and conflict management support is not provided, workers may not be able to navigate the hurdles of working collectively [31].

Whilst organisation into cooperative groups is widely promoted as a method of improving working conditions, the cooperatives identified in the case studies (even those with contracts with local authorities) did not necessarily provide improvement of income to above the national minimum wage, and in some cases demonstrated a high turnover of members as a result, which challenged the sustainability of their operation [29, 30, 32].

Whilst the majority of case studies described LA support and intervention with formalised groups of IWMRS workers, there were also examples of effective efforts to support autonomous individuals who do not want to formalise their activities. These include the carroceiros of Belo Horizonte [19], and the support offered to the autonomous workers of Buenos Aires [33].

Case Studies and Literature

Firstly, it should be noted that the focus of papers and case studies retrieved from the systematic literature review are not proportionally representative of the IWMRS as a whole. Whilst the majority of papers and case studies focus on cooperative groups operating a recyclables collection service with a positive, engaged relationship with their local authorities and material and monetary support, only a minority of individuals operating in the IWMRS are part of such organisations.

Reasons for this disproportionate representation in the literature could include cooperative organisations being a more approachable and researchable type of entity than autonomous workers. Information about a cooperative group can be gathered relatively quickly by reporting to the cooperative premises or headquarters, and having a conversation with management committee staff, who are clearly defined within the cooperative structure. In contrast, gaining a representative picture of autonomous recyclers operating in a city might involve extensive journeys on foot to locate and interview recyclers.

A second reason could be related to willingness to talk to researchers. Autonomous recyclers are frequently noted in studies to be wary and cautious of figures of authority (real or perceived), due to a history of victimisation and harassment from officials [34]. Parizeau noted that in a survey of 397 recyclers in Buenos Aires there was a 17% refusal rate [35]. Cooperative groups, on the other hand, have undergone a process of formalisation to get legitimate status, and therefore might be more receptive to interviews.

A third reason could be the heavy promotion of the cooperative organisational structure to informal recyclers and waste workers by local/regional/national authorities and other supporting organisations as a method to improve working conditions and relations with authorities, thus generating interest in the functioning and activities of these groups.

It should be noted that whilst a majority of case studies referred to organisations as 'cooperatives', it was not always clear whether the cooperative was defined as such in law (i.e. legally registered as a cooperative entity), or was an unregistered group functioning in the spirit of a cooperative (e.g. communal management, and ownership perceived as equal). Some case studies noted that whilst a group was legally registered as a cooperative, in practice, the requirements in relation to tax and receipts were not precisely followed [32].

Only a small number of case studies reported that workers received an income in excess of the national minimum wage. Large wage fluctuations were also mentioned, in connection with the variable price of recyclables [29], which in some cases undermined the economic sustainability of projects [26]. A sizable proportion of case studies did not reveal details about the income of workers, making it difficult to assess the relative economic success of their ventures.

In the majority of case studies, the local authorities were (periodically) engaged with the informal sector, supporting their activities and trying to include them as part of the city solid waste management system. This was sometimes disrupted during changes in administration, leading to relationships having to be rebuilt [25]. An attitude of repression on the part of the city authorities was only reported in one case study, Medina [20], and this is noted to be considerably older than the rest of the case studies and may no longer represent reality.

In general, it was difficult to determine precise information relating to the case studies – both in their operational structure, and general aspects of their management, contractual arrangements, worker characteristics, and formulation. This meant that some aspects had to be inferred from partial information, and many potential case studies were excluded on the basis of incomplete information.

Operational Models Typology

Defining a typology of operational models within the IWMRS was challenging, given the deficit of case study detail and significant amount in activities, sources of material, resources, interactions with customers and buyers, organisational structure, incomes, contractual arrangements, relationships with authorities, and external support. A basic typology of 4 different operational models has been determined (**Table 3**), along with 10 common configurations (**Table 4**). Case studies of each operational model are presented, in the context of other aspects of their operations (**Figures 3-8**).

Operational model *Type IV*, recyclables collection service, was most heavily represented in case studies and literature. This operational model appears to be particularly amenable to contractual partnership with LAs, although notable examples of successful interventions and partnerships between LAs and the IWMRS was also noted for *Type I* - waste collection service [19], *Type II* - waste collection service with recyclables separation [14], and *Type III* - recyclables collection [33]. Examples were noted of autonomous workers operating *Type III* being loosely affiliated to formalised cooperative groups running *Type IV* models in order to offer a flexible but supportive route to improvement of their working conditions [15, 23, 33].

Limitations of study

The main limitation of this study is that it was constrained to literature sources available in English, but covers a geographical area where Spanish and Portuguese are the dominant languages. Thus, a large body of relevant literature was inaccessible. A further limitation was that a lot of valuable information about the organisational and operational dynamics of IWMRS actors is not contained in literature at all, and must be accessed by speaking directly to recyclers and waste actors, and therefore cannot be detected from a literature review alone.

Finally, there were time and resource limits in the extent to which grey literature could be pursued, and therefore a tactical approach of hand-searching websites of prominent organisations was employed.

Conclusions

Workers acting in the IWMRS are diverse in terms of activities, workforce and employment characteristics, affiliation, motivations, and contractual arrangements, in addition to operating within different commercial and political environments. Due to this diversity of elements and characteristics, it is challenging to determine a typology of operational models. In addition, a deficiency of detail in case studies available in the English language limited the realistic conclusions that could be drawn. However, a set of 4 basic operational models, and 10 commonly realised configurations, were identified and elaborated (see **Tables 3 and 4**). Within the case studies examined, cooperative groups tend to employ a *Type IV* operational model (recycling service), and local authorities tend to engage with and formalise services around a *Type IV* operational model. There is clearly a need to increase the extent of this evidence base and, given the disproportionate focus on cooperative-based informal-sector waste and recycling activities, more focus should be given to the role of autonomous informal recyclers, who represent the greater proportion of informal workers in this sector.

Acknowledgments

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