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Disposable and reusable instruments in dental health practice: A comparison of cost factors in a public provider organization in Queensland, Australia

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Abstract

Objectives: Choosing between reusable instruments (RIs) and disposable instruments (DIs) for dental care provision requires a careful consideration of costs and their contributing factors, alongside other choice criteria. This study aimed to assess the current use of instruments in the West Moreton Oral Health Service (WMOHS) in Queensland, Australia, with a broader goal of informing future practice in this and comparable organizations.

Methods: A cost model was developed reflecting costs arising from procurement, reprocessing and disposal, depending on the RI and DI composition of instrumentation. The current practice in WMOHS was compared to modular (RI-only and DI-only) strategies by considering four standard instrument sets (examination, simple extraction, surgical extraction, restoration) and the annual use of instruments in the organization at large. The use of resources (water, electricity) and emissions (waste) were quantified for each strategy. The robustness of findings was explored across a range of scenarios that involved varying instrument prices, lifespans, factors impacting on the cost of reprocessing (labour, water, energy), the cost of waste disposal and couriering.

Results: At the organization level, the current mix of instruments (A$1.28 m per year) was 4% more costly than the lower cost, RI-only alternative (A$1.23 m). However, with lower DI prices or higher labour costs current practice would become the lowest cost option. Results for specific instrument sets varied by service type. DI-only offered the lowest cost option for oral examinations (A$6.29), and the current practice of mixed instrumentation for simple extractions (A$16.56). RI-only sets were less costly in more resource intensive procedures such as surgical extractions (A$40.19) and restorations (A$43.83). In terms of environmental impacts, the use of instruments based on current practice required 37% of water and energy use of an RI-only alternative and generated 36% waste of the DI-only alternative.

Conclusions: Reusable instruments are generally less costly than DIs, but for specific instrument sets the outcome depends on the type of procedure. In some circumstances, mixed instrumentation can provide the lowest cost alternative. While the WMOHS instrument mix used in current practice does not minimize cost for the provider, it may be justified in light of operational risks, logistics and uncertainty regarding cost factors.

KEYWORDS
cost, economic evaluation, environmental impact, reprocessing, reusable instruments, single-use devices, waste

1 | INTRODUCTION

Practitioners and administrators in dental care organizations are required to assess relative advantages of reusable instruments (RIs) and disposable instruments (DIs). While the choice of RIs or DIs in dental practice is primarily driven by clinical and financial criteria, perceptions of factors such as quality, reliability and environmental impacts of the alternatives may also affect the choice. Environmentally conscious decision makers may find the use of RIs appealing due to their higher perceived quality and lower generation of waste. However, DIs do not require the durability of reusable alternatives, which lowers the costs of their production and procurement. In surgical applications, the use of DIs has been identified as an opportunity to streamline processes by eliminating time required for reprocessing, which translates into cost-savings.[1] Moreover, the nature of DIs makes them preferred in certain applications, including in remote and mobile service provision, and as a contingency.

Decisions regarding adoption of RIs or DIs must consider a range of potentially conflicting priorities, the relative importance of which may vary depending on perspective. For example, qualitative interviews with dental staff in the UK's National Health Service, exploring the perceived importance of sustainability in dentistry, demonstrated that priority given to waste management protocols, which caused the staff to favour RIs, was counterbalanced by infection control guidelines, which gave preference to DIs.[2] Such considerations mean choosing between DIs and RIs necessarily involves trade-offs. Yet, there is little research to inform decisions in dental care provider organizations.

The aim of the study was to assess the instrument mix used in current practice by West Moreton Oral Health Service (WMOHS), a community-based public provider of dental care, and determine whether adopting an DI-only or RI-only modular strategy may provide an opportunity for reducing the cost of instrumentation. Additionally, the goal was to understand comparative cost factors, some of which have relevance to the discussion of environmental impacts of dental health services. The following research questions were formulated:

1. Which of the three instrument strategies (current practice, RI-only, DI-only) is most advantageous from a cost perspective, and does the answer depend on the type of service?
2. What is the relative contribution of procurement, reprocessing and disposal to the overall cost of instrumentation?
3. How do the three strategies compare in terms of their use of energy and water, and the generation of waste?
4. Are the findings sensitive to changes in key economic parameters of WMOHS operation, such as the cost of labour, electricity and water?

No comparative cost analyses of the reusable and disposable options have been reported in the literature to date. Moreover, the evidence of environmental impacts specific to dental care is limited. One lifecycle assessment compared single-use and reusable burs and found that the environmental impact of RIs under optimal operational efficiency of autoclaves and ultrasonic cleaners was 40% lower than that of DIs. However, this advantage diminished with lower processing efficiency, and was lost when the ultrasonic cleaner and the autoclave were loaded to only 66% capacity. Under these conditions, the comparative impacts of the two types of burs were mixed across a range of criteria. When processing was below 33% of the loading capacity, disposable burs had lower environmental impacts.[3]

Given limited evidence from dental practice, lifecycle assessment studies from other settings may provide indicative information to guide considerations regarding dental care delivery.[4] Relative to single-use isolation gowns, reusable isolation gowns required 28% less energy, 41% less freshwater, generated 30% less greenhouse gas emissions and 93% less solid waste.[5] A study comparing reusable steel, single-use steel and single-use plastic surgical scissors found that, due to extraction and manufacturing, single-use steel scissors required the most energy and had 13 times higher environmental impact than reusable steel scissors, and 2–10 times higher impact than single-use plastic scissors. The total cost to the provider was the lowest for reusable scissors, and among disposable alternatives steel scissors were 12% less costly than plastic ones.[6] Further evidence is available regarding specialized instruments used in a range of surgical procedures including laparoscopy,[7] laryngoscopy,[8] anaesthesia,[9] catheter insertion,[10] cataract[11] and spinal fusion surgery.[12] Overall, lifecycle assessments appear to favour RIs in terms of environmental impacts[7] and financial analyses point to RIs being less costly.[6–10] However, the extent to which evidence from such diverse healthcare settings is relevant to dental care is unclear.

This study was motivated by a change in Australian national standards for reprocessing of reusable medical devices, which became effective in 2017.[13,14] The new standard resulted in benchtop sterilizers being removed from points of provision and the adoption of a centralized sterilization model by the provider organization, with 28 facilities couriering used instruments to the centralized sterilization department (CSD) for reprocessing. This raised questions about whether long-term strategy should favour the adoption of reusable or disposable instruments. The CSD is located onsite at the main 11-chair dental clinic. The distance between the CSD and other facilities ranges from 3 to 72 km. Of the other 28 facilities, there are two 3-chair dental clinics, two 2-chair clinics and the other 24 clinics operate a single dental chair. Not all facilities are open each day, with staff rotated through clinics to balance access to care across the service. A courier service visits each open facility each day to exchange instruments and deliver clinical supplies and internal mail. WMOHS provides approximately 15 000 emergency, general and denture care appointments annually to eligible members of the community. Eligible groups include children, pensioners and seniors, and Healthcare Card holders representing a range of circumstances qualifying the individual for welfare support, such as low income or unemployment. Services are offered at hospitals, community clinics and schools in the West Moreton region, and are free of charge at the point of delivery. WMOHS operates under the jurisdiction of West Moreton Hospital and Health Service, a local health authority, which is part of Queensland Government Department of Health, a state-wide public healthcare provider in Queensland, Australia.

2 | METHODS

Costs were estimated for two alternative strategies, a RI-only strategy and a DI-only strategy, in order to inform decision makers about possible future directions. Neither of the exclusive strategies reflects current activities and hence cannot be informed by existing provider costs. Costs for the current practice were estimated using the same model to enable comparisons. The costing model, developed to determine the cost of instrumentation depending on its RI and DI composition, was based on the identification of key contributing cost factors (Figure 1). These factors are procurement, reprocessing and disposal. Modelling the procurement cost of instrumentation required understanding the types and numbers of services provided, instruments required for each service type, their expected number of lifetime uses and prices. The reprocessing cost of instrumentation accounted for the use of electricity and water, labour inputs and couriering. The disposal cost of instrumentation was based on an outsourced waste management process in which cost is a function of the weight of instruments. Each strategy was modelled by exploring the variation in these costs depending on the RI and DI composition of the overall instrumentation.

The comparative analysis was performed on two levels: the micro level, looking at four standard sets of instruments used in day-to-day service delivery, and the macro level, simulating the adoption of an overarching strategy in the organization at large, based on its annual volume of services. The four standard sets of instruments were oral examination (49% of services annually), simple extraction (12%), surgical extraction (1%) and restoration (38%). The instruments used in each standard set, presented in Table 1, are based on current practice and actual use as recorded by WMOHS.

The comparative analysis rested on several key considerations. The typical lifespan and repair costs of instruments vary depending on the manufacturing quality and the conditions and frequency of use.[15] In the analysis presented here, the lifespan range reflected the typical number of instrument uses recorded in WMOHS, which internalized instrument replacement rate due to wearing as well as

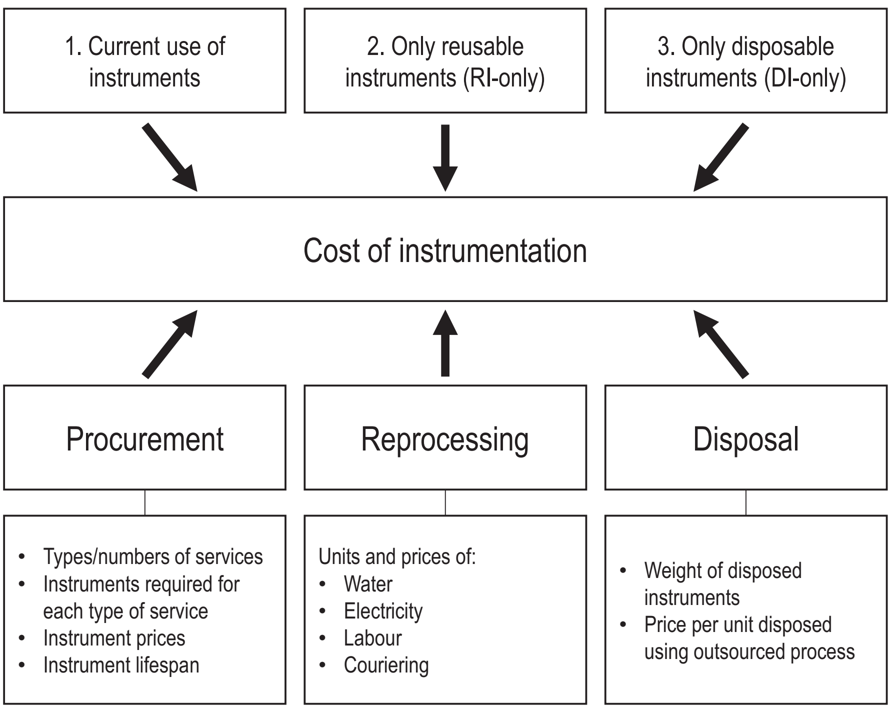

FIGURE 1 Overview of the comparative modelled cost analysis

TABLE 1 Instrument characteristics and composition of instrument sets

Instrument	Price (A$)	Weight (g)	Lifespan (years)	Life uses (count)	Instrument set 1	2	3	4
Reusable								
Artery forceps	36.96	65	5 to 10	2500–5000			1	
Ball burnisher	16.04	22	5 to 10	2500–5000				1
Bur – elcomed[b]	1.8	2	NA	1			1	
Cryer	36.13	66	5 to 10	2500–5000			1[a]	
Dycal applicator	4.2	16	5 to 10	2500–5000				1
Extraction forceps	89.67	157	5 to 10	2500–5000		1[a]	1[a]	
Flat plastic	30.51	22	5 to 10	2500–5000				1
Handpiece – surgical	1350	142	5 to 10	2500–5000			1[a]	
High speed burs	1.58	2	3 months	125				1
High speed handpiece	787.86	42	up to 10	2500–5000				1[a]
Luxator	36.57	74	5	2500		1[a]	1[a]	
Mandrels	7.87	2	2	1000				1[a]
Matrix retainer	22.76	15	5 to 10	2500–5000				1[a]
Mirror	24.32	28	5 to 10	2500–5000	1	1	1	1
Periosteal Elevator	34.57	27	6 months	250		1[a]	1[a]	
Retractor – Minnesota	59.63	25	1	500			1[a]	
Rubber dam clamp	13.4	6	5 to 10	2500–5000				1[a]
Rubber dam forceps	123.79	50	5 to 10	2500–5000				1[a]
Rubber dam frame	6.91	26	5 to 10	2500–5000				1[a]
Scalpel handle	24.16	80	5 to 10	2500–5000			1	
Scissors	71.91	65	3	1500			1	
Sickle Probe	6.11	20	5 to 10	2500–5000	1	1	1	1
Slow speed burs[b]	1.08	2	NA	1				1
Slow speed handpiece	403.03	80	up to 10	2500–5000				1[a]
Spoon excavator	17	19	5 to 10	2500–5000				1
Syringe	77.81	85	5 to 10	2500–5000		1[a]	1[a]	1
Tissue forceps	188.28	20	5 to 10	2500–5000			1	
Tweezer (London College)	12.92	23	5 to 10	2500–5000	1	1	1	1
Disposable								
Artery forceps	4.68	34	NA	1			1[a]	
Ball burnisher	2.16	12	NA	1				1[a]
Bur – elcomed	8.39	4	NA	1			1[a]	
Cryer[b]	11	85	NA	1			1	
Double ended Probe	2.12	5	NA	1	1[a]	1[a]		
Dycal applicator	1	5	NA	1				1[a]
Extraction Forceps[b]	12	140	NA	1		1		
Flat plastic	2.16	10	NA	1				1[a]

(Continues)

TABLE 1 (Continued)

Instrument	Price (A$)	Weight (g)	Lifespan (years)	Life uses (count)	Instrument set 1	2	3	4
Forceps[b]	12	140	NA	1			1	
Handpiece – surgical[b]	16	85	NA	1			1	
High speed bur	2.12	2	NA	1				1[a]
High speed handpiece[b]	7	85	NA	1				1
Luxator[b]	11	85	NA	1		1	1	
Mandrels[b]	0.46	2	NA	1				1
Matrix band + retainer	6.96	15	NA	1				1
Mirror	1.83	5	NA	1	1[a]	1[a]	1[a]	1[a]
Periosteal elevator	8.88	32	NA	1		1	1	
Probe	2.12	5	NA	1			1[a]	
Retractor – Minnesota	3.99	25	NA	1			1	
Rubber dam clamp[b]	1.2	6	NA	1				1
Rubber dam forceps[b]	19.95	60	NA	1				1
Rubber dam frame	4.12	15	NA	1				1
Scalpel	1.29	7	NA	1			1[a]	
Scissors	1.05	17	NA	1			1[a]	
Sickle Probe	2.12	5	NA	1				1[a]
Slow speed bur	0.46	2	NA	1				1[a]
Slow speed handpiece[b]	12	85	NA	1				1
Spoon excavator	2.16	10	NA	1				1[a]
Syringe	13.43	85	NA	1		1	1	1[a]
Tissue forceps	3.07	27	NA	1			1[a]	
Tweezer (London College)	2.32	25	NA	1	1[a]	1[a]	1[a]	1[a]

Note: Instrument sets: 1 Oral examination; 2 Simple extraction; 3 Surgical extraction; 4 Restoration.
Abbreviation: NA, not applicable.
[a]Indicates whether a disposable or reusable instrument is used in the current WMOHS instrument mix for the respective procedure.
[b]Supplier data not available; information supplemented from market research.

damage occurring during transportation.[12] Similar to most instrument lifecycle analyses, the wastage of opened but unused items was not quantified due to the lack of data and its relatively minor impact.[16]

Repair costs have been reported in the literature and, for most surgical instrument sets, are small but not negligible.[17,18] In this study, the costs of maintenance and repair were not explicitly modelled. While the information provided by WMOHS included maintenance contracts, it did not separate costs of instrument upkeep from other costs, such as equipment installation and calibration. Moreover, identification of repair needs, an integral part of maintenance activity, is largely performed during the process of sterilization and cleaning, leading to instruments being readily repaired or discarded and replaced. For the above reasons, most of RI repair costs were indirectly captured through the cost of labour, and any costs that remained unaccounted for were deemed insignificant for the scope and purpose of this study.

Finally, RIs and DIs were assumed to offer the same level of safety in terms of patient outcomes. While studies have suggested that DIs may offer a reduced risk of contamination and improved infection control,[19,20] the existing evidence on this issue is small and does not represent dental care applications. Furthermore, WMOHS never experienced safety issues relating to RI use.

All data to inform the analysis were provided by WMOHS based on administrative records for financial year 2019–20, including the types and characteristics of instruments, types and numbers of dental care procedures, as well as utilization of reprocessing inputs and their respective prices. Because the information was sourced centrally, data collection did not involve contacting individual points of provision or staff interviews.

The cost of RI reprocessing was determined as $2.48 per instrument, with sterilization and cleaning performed at 96% capacity on average. Details of this are provided in the Appendix S1 (Table S1). Because this study did not aim to improve the sterilization process, it was assumed that the efficiency and cost of reprocessing would not change with the volume of instruments. Data to support this assumption are provided in the online Appendix S1 (Figure S1). Departures from the assumed value are explored via sensitivity analyses.

The robustness of findings was investigated by varying the input values in one-way sensitivity analyses. Inputs under consideration correspond to factors indicated in Figure 1 and include instrument prices, instrument lifespans, the cost of waste disposal, as well as inputs into instrument reprocessing (labour, water, electricity and couriering). The response of cost outcomes to changes in input parameters was explored in a ±30% range around their base values, except for the costs of water and energy, which were doubled, and waste disposal, the cost of which was increased 10-fold due to its low base value.

All costs are expressed in Australian dollars. The average exchange rates for A$1 over the study period were US$0.69, EUR0.62, UK£0.54 and CAN$0.92.[21]

3 | RESULTS

Costs of the four base instrument sets for the current practice, RI-only and DI-only configurations are presented in Table 2. For oral examination, current practice and DI-only were equivalent and had the lowest cost ($6.29). In the case of simple extraction, current practice was the option with the lowest cost ($16.56), followed by RI-only and DI-only. For surgical extraction, RI-only ($40.19) had the lowest cost, followed by current practice and DI-only. In restoration services, RI-only ($43.83) was the least costly option. The driving cost factors for instrument sets were acquisition, which explained 99.7% of the total cost in DI-only, and reprocessing, which accounted for 96.4% of the cost in RI-only sets. The cost of waste disposal averaged 0.6% (range 0.3%–1.2%) of the total cost across all four instrument sets.

Table 3 presents the estimated total annual cost of instruments at the organization level. For current practice, this amounted to $1 278 793, including $845 819 (66.1% of the total) for instrument acquisition, $430 695 (33.7%) for reprocessing and $2280 (0.2%) for disposal. The RI-only strategy offered a slightly lower total cost of $1 234 641 (3.5% less than current practice) but with a distinct cost structure (considerably lower costs of acquisition, greater costs of reprocessing and negligible costs of waste disposal). By comparison, the DI-only alternative was substantially more expensive with a total cost of $2 243 267 (75% more than current practice). The patterns of resource use and waste generation reflected the structure of costs in the reprocessing and disposal categories (Table 3). Current practice required 801 kl of water and 34.5 mWh of energy and generated 4.6 tonnes of instrument waste. RI-only required 2.7 times more water and energy, but its waste emissions were negligible at 47 kg per year. DI-only did not require water or energy use but generated 12.6 tonnes of waste.

Sensitivity analyses in Table 4 illustrate the fact that the strategy with the lowest cost, and the size of its relative advantage, can change in some scenarios. RI-only was preferred in the base case and its advantage increased under declining cost of labour and increasing DI prices. Current

TABLE 2 Cost (A$) of instrument set, by type

Type	Depreciation	Reprocessing	Disposal	Total	Δ
Set 1: Oral examination					
Current practice	6.27	0.00	0.02	6.29	ref.
RI-only	0.01	7.43	0.04	7.47	+19%
DI-only	Equivalent to current practice				
Set 2: Simple extraction					
Current practice	6.47	9.90	0.19	16.56	ref.
RI-only	0.21	17.33	0.21	17.75	+7%
DI-only	51.58	0.00	0.19	51.77	+213%
Set 3: Surgical extraction					
Current practice	25.44	17.33	0.35	43.12	ref.
RI-only	2.61	37.14	0.44	40.19	−7%
DI-only	101.05	0.00	0.33	101.38	+135%
Set 4: Restoration					
Current practice	30.13	17.33	0.20	47.66	ref.
RI-only	1.51	42.09	0.23	43.83	−8%
DI-only	81.45	0.00	0.21	81.66	+71%

practice had the potential to be the lowest cost strategy, given sufficient DI price reductions or labour cost increases. Setting the daily courier cost to zero led to a 26% reduction in unit reprocessing cost ($1.83), resulting in RI-only becoming relatively more attractive. Changes in RI prices, their lifespans, the cost of waste disposal and the water and energy costs of instrument reprocessing, did not have a significant impact on the results. Notably, DI-only was the highest cost option in all scenarios.

4 | DISCUSSION

The analysis compared the existing, mixed use of instruments to strategies relying exclusively on disposable or reusable instruments, with the aim of evaluating current practice in WMOHS and informing future decisions. Adopting RIs emerged as the least costly overarching strategy, although the benefits of its exclusive adoption depend on parameters such as relative instrument prices, the cost of labour, and the water and energy use in reprocessing. The picture is more nuanced regarding the four specific instrument sets. While RI-only sets represent the lowest cost choice for resource-intensive services, such as surgical extraction and restoration, a DI-only set is less costly for oral examinations, and the current mixed set is less costly for simple extractions.

To our knowledge, this is the first study to provide a comprehensive comparative cost analysis of instrumentation in a dental care provider organization. Its structured approach establishes factors contributing to the cost of instrumentation and bridges the gap in understanding of relative merits of RIs and DIs. The counterfactual strategies of RI-only and DI-only represent two extremes, neither of which is likely to be fully implemented in practice, but they both serve to illustrate the magnitude of potential consequences of such decisions. While focusing primarily on cost to provider, the analysis also sheds light on the comparative reliance on water and electricity, and contributions to emissions, of each strategy. RI-only and DI-only strategies support competing environmental priorities, the latter generating more waste but offering advantages in terms of lower water and electricity use associated with service provision. One advantage of the present instrument mix is that it requires 37% of water and energy use of an RI-only alternative while generating 36% waste of an DI-only alternative. In a validation step concerning the modelled use of resources and emissions against published data, the

TABLE 3 Costs and their drivers, WMOHS per year

	Current practice	RI-only	DI-only
Financial costs (A$)			
Procurement	845 819	34 263	2 236 972
Reprocessing	430 695	1 200 354	0
Disposal	2280	24	6295
Total	1 278 793	1 234 641	2 243 267
Change	ref.	−3.5%	+75.4%
Emissions			
Water use (L)	800 800	2 173 600	0
Energy use (kWh)	34 535	93 737	0
Waste (kg)	4559	47	12 590

TABLE 4 Sensitivity analysis – total cost of instrumentation for alternative input parameter values

Scenario	Current practice	RI-only	DI-only	Δ[a] (%)
Base case[b]	1 278 793	**1 234 641**	2 243 267	−3.5
(1) DI price −30%	**1 027 831**	1 234 641	1 572 175	0.0
(2) DI price +30%	1 529 755	**1 234 641**	2 914 359	−19.3
(3) RI price −30%	1 278 408	**1 224 362**	2 243 267	−4.2
(4) RI price +30%	1 279 178	**1 244 920**	2 243 267	−2.7
(5) RI lifespan −30%	1 282 770	**1 239 371**	2 243 267	−3.4
(6) RI lifespan +30%	1 276 652	**1 232 095**	2 243 267	−3.5
(7) Cost of labour −30%	1 186 499	**977 416**	2 243 267	−17.6
(8) Cost of labour +30%	**1 371 087**	1 491 867	2 243 267	0.0
(9) Cost of waste disposal x10	1 299 309	**1 234 854**	2 299 923	−5.0
(10) Reprocessing water use/cost x2	1 281 289	**1 241 599**	2 243 267	−3.1
(11) Reprocessing energy use/cost x2	1 286 755	**1 256 833**	2 243 267	−2.3
(12) Nil courier cost	1 166 205	**920 856**	2 243 267	−21.0

[a]The base case corresponds to financial cost totals in Table 3.

[b]Percentage change between the lowest cost strategy (bolded) vs current practice in the respective scenario.

results appeared to be plausible considering the size of the provider organization.[3,22,23]

Key limitations of the study relate to elements not captured in the modelled analysis, and to its limited generalizability. The costs of transportation were reflected across different categories, including procurement, which includes the costs of shipping, reprocessing, which accounts for courier runs, and disposal, which internalizes transport to and from the provider organization. While it would be informative to report emissions associated with transportation as a separate outcome, such analysis would require the knowledge of sources of instrument importation, a detailed spatial mapping of WMOHS services, locations of landfills or waste incineration sites, and various modes of transportation. These were outside the scope of the present analysis, but it is likely that their importance is limited, in light of a recent study showing that transportation has minor impacts on lifecycle emissions for both reusable and disposable products.[12] Furthermore, the presented analysis does not consider emissions associated with instrument packaging, due to a lack of reliable information. In the absence of information specific to dental care, it is informative to note that the packaging of dental instruments per procedure would plausibly fall within the range indicated by a pathology test[24] and dermatology surgery.[25] This, however, would be comparable for DI-only and RI-only strategies because RIs are also individually wrapped after reprocessing. Both approaches contribute to the problem of packaging-related waste, an issue that may be alleviated by aligning with Australia's 2025 national sustainable packaging targets.[26] Lifecycle analysis, which focuses on different questions than the approach employed in this study, would be better suited for exploring these problems.

While its findings fill an important knowledge gap, the study was informed by circumstances specific to WMOHS which may limit its generalizability to other organizations, settings and jurisdictions. Firstly, WMOHS is a decentralized organization with a major central clinic surrounded by several predominantly single-chair points of service provision such as schools and mobile units. This 'hub-and-spoke' service model is not unique to WMOHS but it has implications for the cost analysis and may limit the generalization of its results. The sensitivity analysis that removed the courier cost (Table 4) addressed this issue to some extent, by making the modelled provider organization equivalent to that of a single site with unchanged types and numbers of services. Secondly, the study is concerned with annual running costs of instrumentation and assumes away capital outlays in the form of additional instrument stock, which would be required to enable the RI-only strategy. Accounting for the cost of additional instrumentation would bias results against the RI-only strategy, particularly in the short run, but would become less significant over longer time horizons that were not analysed here. These costs are also difficult to approximate as the need for additional instrumentation would depend on the organization of service provision and detailed logistics of reprocessing. Thirdly, in the case of WMOHS, increasing the volume of RIs does not require expanding reprocessing capacity. Consequently, the analysis only considered additional variable inputs of labour, water and electricity. In other dental care provider organizations creating additional capacity (including space and equipment) may represent a considerable capital outlay, which would reduce the relative advantage of the RI-only strategy in the short term. In such cases, context-specific economic analysis is warranted, and outsourced reprocessing may represent a viable alternative.

While the current practice of instrument use by WMOHS does not minimize cost, its advantages may justify the expense of 4% above the lowest cost alternative. Involving both types of instruments in service provision introduces a degree of flexibility that may help to manage operational risks. For example, a sudden interruption in the global supply chain for DIs, supply shortages and spikes in demand, may severely affect organizations that rely exclusively on DIs. Conversely, organizations that solely depend on RIs may not be able to respond to supply issues concerning inputs to the sterilization and cleaning process, such as consumables, equipment or availability of qualified staff. Failing to diversify may therefore constitute a hidden economic cost associated with exposure to these risks. A mixed strategy hedges risks and provides options for contingency planning, which may justify the additional cost. Finally, the adoption of a mixed strategy such as the one used in the current practice of WMOHS reflects practical necessities associated with factors not explicitly modelled in this study, such as provision of services by mobile dental health units where full reliance on RIs may be prohibitively costly.

The analysis also identifies circumstances in which the cost of RIs may be comparable to, or higher than that of DIs. These results complement findings from previous studies that warn against taking the benefits of RIs for granted. Key factors affecting comparative cost outcomes include not only the type and volume of services, but also the efficiency of instrument reprocessing. While RIs present providers with an opportunity to actively manage their environmental impacts and strive for efficiency in resource use, they also introduce the possibility of waste.[3] Because maintaining high reprocessing standards is costly, adopting the less demanding DI flow may be advantageous in some situations.[12]

Reusable instruments are sometimes favoured due to higher perceived quality of materials and more consistent performance. This, however, is a multifaceted issue. Disposable sharp devices such as trocars or scissors have been shown to be more effective and less vulnerable to failure than reusable devices.[7] On the other hand, extra force and time required with reusable instruments, although it may increase effort exerted by providers, does not necessarily translate to inferior patient-relevant outcomes.[27] Another argument against RIs is that the design of some instruments may inhibit their cleaning. In some cases steam sterilization can help ensure that instruments are sterile after autoclaving even when debris remains.[28] Studies have reported increased risk of surgical site infections when RIs were used, and claimed that sterile DIs had a lower surgical site infection rates.[1] However, the risk of infections is generally low for a dental practice[29] and following standard protocols for reprocessing substantially mitigates any remaining risks.[30] Overall, the evidence of instrument quality implications for health outcomes and occupational health, which can also be conceptualized as costs, is limited and inconclusive.

5 | CONCLUSIONS

In WMOHS, the current practice of mixed instrumentation minimizes cost for simple extractions and DI-only does so for oral examinations. RIs are the lowest cost option in the other procedures investigated, which are generally more resource intensive. The choice between maintaining current practice and adopting an RI strategy by the organization at large hinges on two key economic factors: the cost of labour and DI prices. A mixed strategy that does not minimize cost may be justified considering operational risks, logistics and uncertainty of cost factors. While these results may not be easily generalizable due to WMOHS-specific characteristics such as its 'hub-and-spoke' structure, the approach to economic modelling presented in this study offers a methodology that can be used in other service configurations.

AUTHOR CONTRIBUTIONS

PMS, JF, KMG and SB contributed to the study conception and design, data acquisition and interpretation, analyses and drafting of the manuscript. All authors gave their final approval and agreed to be accountable for all aspects of the work.

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CONFLICT OF INTEREST

None.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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REFERENCES

1. Goldberg TD, Maltry JA, Ahuja M, Inzana JA. Logistical and economic advantages of sterile-packed, single-use instruments for total knee arthroplasty. *J Arthroplasty*. 2019;34(9):1876-1883.
2. Grose J, Richardson J, Mills I, Moles D, Nasser M. Exploring attitudes and knowledge of climate change and sustainability in a dental practice: a feasibility study into resource management. *Br Dent J*. 2016;220(4):187-191.
3. Unger SR, Landis AE. Comparative life cycle assessment of reused versus disposable dental burs. *Int J Life Cycle Assess*. 2014;19(9):1623-1631.
4. Miettinen P, Hämäläinen RP. How to benefit from decision analysis in environmental life cycle assessment (LCA). *Eur J Oper Res*. 1997;102(2):279-294.
5. Vozzola E, Overcash M, Griffing E. Environmental considerations in the selection of isolation gowns: a life cycle assessment of reusable and disposable alternatives. *Am J Infect Control*. 2018;46(8):881-886.
6. Ibbotson S, Dettmer T, Kara S, Herrmann C. Eco-efficiency of disposable and reusable surgical instruments—a scissors case. *Int J Life Cycle Assess*. 2013;18(5):1137-1148.
7. Siu J, Hill AG, MacCormick AD. Systematic review of reusable versus disposable laparoscopic instruments: costs and safety. *ANZ J Surg*. 2017;87(1–2):28-33.
8. Sherman JD, Raibley LA IV, Eckelman MJ. Life cycle assessment and costing methods for device procurement: comparing reusable and single-use disposable laryngoscopes. *Anesth Analg*. 2018;127(2):434-443.
9. McGain F, Story D, Lim T, McAlister S. Financial and environmental costs of reusable and single-use anaesthetic equipment. *Br J Anaesth*. 2017;118(6):862-869.
10. McGain F, McAlister S, McGavin A, Story D. A life cycle assessment of reusable and single-use central venous catheter insertion kits. *Anesth Analg*. 2012;114(5):1073-1080.
11. Thiel CL, Schehlein E, Ravilla T, et al. Cataract surgery and environmental sustainability: waste and lifecycle assessment of phacoemulsification at a private healthcare facility. *J Cataract Refract Surg*. 2017;43(11):1391-1398.
12. Leiden A, Cerdas F, Noriega D, Beyerlein J, Herrmann C. Life cycle assessment of a disposable and a reusable surgery instrument set for spinal fusion surgeries. *Resour Conserv Recy*. 2020;156:104704.
13. Standards Australia. Office-based health care facilities – Reprocessing of reusable medical and surgical instruments and equipment, and maintenance of the associated equipment (AS/NZS 4815:2006). Standards Australia; 2006.
14. Standards Australia. *Reprocessing of reusable medical devices in health service organisations* (AS/NZS 4187:2014). Standards Australia; 2014.
15. Heimbach J, Thomas CA. *Instrument Replacement: How, When, & Why?* Registered Dental Hygienist; 2008.
16. Zygourakis CC, Yoon S, Valencia V, et al. Operating room waste: disposable supply utilization in neurosurgical procedures. *J Neurosurg*. 2017;126(2):620-625.
17. Stockert EW, Langerman A. Assessing the magnitude and costs of intraoperative inefficiencies attributable to surgical instrument trays. *J Am Coll Surg*. 2014;219(4):646-655.
18. Skogås J, Mårvik R. Measures taken to reduce damage and repair costs of rigid endoscopes during their handling and processing in surgical practice. *Minim Invasive Ther Allied Technol*. 2003;12(1–2):76-81.
19. Dancer SJ, Stewart M, Coulombe C, Gregori A, Virdi M. Surgical site infections linked to contaminated surgical instruments. *J Hosp Infect*. 2012;81(4):231-238.
20. Al-Jandan BA, Ahmed MG, Al-Khalifa KS, Farooq I. Should surgical burs be used as single-use devices to avoid cross infection? A case-control study. *Med Princ Pract*. 2016;25(2):159-162.
21. Australian Taxation Office. Foreign currency exchange rates for financial year ending 30 June 2020; 2020.
22. Farahani A, Suchak M. *Eco-Friendly Dentistry, the Environmentally Responsible Dental Practice*. University of Waterloo; 2007:3.

23. Farmer GM, Stankiewicz N, Michael B, et al. Audit of waste collected over one week from ten dental practices. A pilot study. *Aust Dent J*. 1997;42(2):114-117.
24. McAlister S, Barratt AL, Bell KJ, McGain F. The carbon footprint of pathology testing. *Med J Aust*. 2020;212(8):377-382.
25. Tan E, Lim D. Carbon footprint of dermatologic surgery. *Aust J Dermatol*. 2021;62(2):e170-e177.
26. Australian Packaging Covenant Organisation. *Sustaintable Packaging Guidelines (version 3, updated October 2020)*. Australian Packaging Covenant Organisation; 2020.
27. Corson SL, Batzer F, Gocial B, Maislin G. Measurement of the force necessary for laparoscopic trocar entry. *J Reprod Med*. 1989;34(4):282-284.
28. Apelgren K, Blank M, Slomski C, Hadjis N. Reusable instruments are more cost-effective than disposable instruments for laparoscopic cholecystectomy. *Surg Endosc*. 1994;8(1):32-34.
29. Laheij A, Kistler J, Belibasakis G, Välimaa H, De Soet J, Workshop EOM. Healthcare-associated viral and bacterial infections in dentistry. *J Oral Microbiol*. 2012;4(1):17659.
30. Southworth P. Infections and exposures: reported incidents associated with unsuccessful decontamination of reusable surgical instruments. *J Hosp Infect*. 2014;88(3):127-131.

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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