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Bridging the green gap: knowledge and practices of sustainable healthcare among medical and dental students of Khyber Pakhtunkhwa, Pakistan

Abdul Manan^a, Sadia Rashid^b, Muhammad Jahangir Khan Bhatti^c, Muhammad Adnan Iqbal^d, Syed Abir Hussain^e, Muhammad Azhar^f.

^aAssociate Professor, Department of Oral Medicine, Islamic International Dental College, Islamabad.

^bProfessor, Department of Physiology, Frontier Medical and Dental College, Abbottabad.

^cSenior Registrar, Department of Community Medicine, Frontier Medical and Dental College, Abbottabad.

^dAssistant Professor, Department of General Medicine, Khawaja Muhammad Safdar Medical College, Sialkot.

^eAssociate Professor, Department of Community Dentistry, Frontier Medical and Dental College, Abbottabad.

^fAssistant Professor, Department of Oral Biology, Army Medical College, NUMS, Rawalpindi.

Corresponding address*: drsadiarizwan@gmail.com

ABSTRACT

BACKGROUND & OBJECTIVE: Environmental destruction resulting from power usage, waste, and resource-intensive practices in the health sector has become a global issue. Eco-friendly notions seem inadequately presented in undergraduate medical and dental programs in developing nations, despite of raised global awareness about eco-friendly health practices. The aim of our study was to assess the knowledge, attitudes, and abilities of undergraduate medical and dental students regarding eco-friendly practices.

METHODOLOGY: A descriptive cross-sectional study was conducted at Frontier Medical and Dental College, Abbottabad, KPK (January–May 2025). A total of 270 students of third-, fourth-, and final-year MBBS, and second-, third-, and final-year BDS completed a pre-validated, closed-ended, 27-item questionnaire. The sampling process involved 290 students, of whom 270 completed the survey (93% response rate). Data were analyzed using IBM SPSS v20.

RESULTS: Out of 290 students invited, a response rate of 93% (N=270) was achieved, with 135 each in BDS and MBBS. A total of 60% recorded energy savings, 77.78 % reflected awareness of recycling practices, and 72.96% had knowledge about waste management despite of practical non-compliance, as 54% still reported disposal of major waste in general Bins. About 78.2% of participants were interested in further training on biomedical waste management. Awareness about waste management appeared higher among BDS Students than MBBS students (77.0% vs 68.9%), though this difference was not statistically significant.

CONCLUSION: Although many medical professionals are aware of green practices like power saving and recycling, gaps between knowledge and practice exist. The addition of training of sustainable healthcare in undergraduate medical and dental education in Pakistan has become essential.

KEYWORDS: Students, Sustainable Development, Attitude, Medical Waste Disposal, Pakistan.

INTRODUCTION

Disruption of ecosystems in the form of extreme weather and temperature rise is increasingly impacting global health^[1-3]. The healthcare sector not only faces these climate challenges, but also contributes to environmental degradation through improper biomedical waste handling and resource-intensive practices^[4,5]. These issues are particularly high in developing nations like Pakistan due to mishandling of such waste^[6,7].

The importance of integrating eco-sustainability into public health planning and development has been prioritized by WHO and UN^[8,9]. The ISO 14000 standards provide guidance for environmental management in healthcare

institutions, and organizations like the FDI World Dental Federation advocate for "green dentistry"^[10,11].

Despite this growing recognition and policy development, sustainability principles are still not widely incorporated into medical and dental training programs, especially in low- and middle-income nations^[12,13]. In Pakistan, the medical and dental curricula address waste management only tangentially, and empirical evidence on students' competencies in sustainable healthcare is entirely scarce. A recent study assessed dental students' knowledge of green dentistry in Pakistan. Still, a comparative analysis of medical and dental students' competencies across a wider range of sustainable practices is lacking^[14].

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This study is the first to evaluate the understanding, perceptions, and implementation of Sustainable environmental principles among Pakistani medical and dental undergraduates in Abbottabad, KPK Province. By highlighting gaps between awareness and practice, this research advocates for curricular reforms to align healthcare education with planetary health imperatives. The results aim to guide curriculum development and inform policy for integrating environmental sustainability into healthcare education.

METHODOLOGY

It was a descriptive cross-sectional study, which was carried out during January- May 2025 at Frontier Medical and Dental College, Abbottabad. The study aimed to assess understanding, perceptions, and implementation related to sustainable healthcare principles among healthcare Students. Ethical approval from the college IRB (EC # FMDC-84-R.A-25) and informed consent Was obtained from the participants. The target population included MBBS (Years 3–5) and BDS (Years 2–4) students. Using OpenEpi software (95% confidence interval, 5% margin of error), a minimum sample size of 270 was calculated from 827 eligible students (623 MBBS, 204BDS). Convenience sampling was employed. A total of 290 students were invited to participate, out of which 270 completed the questionnaire (response rate: 93%), with equal representation from MBBS (n = 135) and BDS (n = 135). Absent and unwilling students were excluded.

Table-II: Energy and resource conservation practices.

Practices	MBBS (n=135) n(%)	BDS (n=135) n(%)	Total n(270) n(%)
Shuts down idle computers	86(63.7)	93(68.9)	179(66.3)
Uses motion-sensing lamps	93(68.9)	89(65.9)	182(67.4)
Uses incandescent bulbs	71(52.6)	72(53.3)	143(53.0)
Does not recycle paper	97(71.9)	106(78.5)	203(75.2)

Table-IV: Biomedical waste management knowledge.

Parameter	Response	MBBS (n=135) n(%)	BDS (n=135) n(%)	Total (n=270) n(%)	P-value
Aware of waste categories	Yes	93 (68.9)	104(77.0)	197 (73.0)	0.132
	No	42 (31.1)	31 (23.0)	73 (27.0)	
Supports colour-coding	Yes	110 (81.5)	116(85.9)	226(83.7)	0.31
	No	25 (18.5)	19 (14.1)	44(16.3)	
Unaware of storage limits	Yes	90 (66.7)	90(66.7)	180(66.7)	1.00
	No	45 (33.3)	45(33.3)	90(33.3)	
Advocates inclusion of sustainability training in curriculum	Yes	110 (81.5)	123(91.1)	233(86.3)	0.02*
	No	25 (18.5)	12(8.9)	37(13.7)	

Chi-square tests for comparison of MBBS/BDS responses; significant differences at *p* < 0.05.

A total of 290 students were invited to participate in the study, of whom 270 completed the questionnaire, for a response rate of 93%. Among the participants, MBBS and BDS each had 135 (50%) participants.

A structured, self-administered, pre-validated questionnaire (Cronbach's $\alpha \geq 0.7$), adapted from Prior studies, was used^[16,17]. The instrument, titled "Sustainable Health Practices questionnaire for health professions students" (SHP-Q), comprised four domains:

1. Demographics: Gender, academic year, and discipline.
2. Power Consumption: Energy-saving behaviours (e.g., use of motion-sensing lights, computer shutdown practices).
3. Recycling Awareness: Knowledge of paper, X-ray foil, and sterilization pouch recycling.
4. Waste disposal: waste management, coding, knowledge and Hep B vaccination.

Responses were recorded on dichotomous (yes/no) and Likert-type scales. The questionnaire was pilot-tested for clarity and reliability.

Data were analyzed using SPSS v20. Descriptive statistics summarized frequencies and percentages. Chi -square tests compared responses between MBBS and BDS cohorts. We considered $p < 0.05$ statistically significant.

RESULTS

Table-I: Participating Medical (MBBS) and Dental (BDS) students by academic year.

Academic year	MBBS (n=135) n(%)	BDS (n=135) n(%)	Total n(%)
2nd year	15 (11.1)	35(25.9)	50(18.5)
3rd year	41(30.4)	29(21.5)	70(25.9)
4th year	46(34.1)	52(38.5)	98(36.3)
5th year (MBBS)/ House Job (BDS)	33(24.4)	19(14.1)	52(19.3)

Table-III: Recycling Awareness and Practices.

Item	Correct Knowledge n(%)	IncorrectUnknown n(%)
Office paper recycling	210(77.8)	60(22.2)
Hospital waste recycling	146(54.1)	124(45.9)
X-ray foil recycling	125(46.3)	145(53.7)
Sterilization pouch recycling	170(63.0)	100(37.0)

Parameter	Response	MBBS (n=135) n(%)	BDS (n=135) n(%)	Total (n=270) n(%)	P-value
Aware of waste categories	Yes	93 (68.9)	104(77.0)	197 (73.0)	0.132
	No	42 (31.1)	31 (23.0)	73 (27.0)	
Supports colour-coding	Yes	110 (81.5)	116(85.9)	226(83.7)	0.31
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Unaware of storage limits	Yes	90 (66.7)	90(66.7)	180(66.7)	1.00
	No	45 (33.3)	45(33.3)	90(33.3)	
Advocates inclusion of sustainability training in curriculum	Yes	110 (81.5)	123(91.1)	233(86.3)	0.02*
	No	25 (18.5)	12(8.9)	37(13.7)	

While awareness of waste disposal appeared higher among BDS students (77.0%) than MBBS students (68.9%), this difference was not statistically significant ($\chi^2=2.27$, $p=0.132$). However, significantly more BDS students

(91.1%) expressed the need to incorporate sustainability training into the curriculum than MBBS students (81.5%) ($\chi^2=5.89$, $p=0.015$). In comparison, we found no significant differences in energy savings (all $p>0.05$) or knowledge about recycling ($p=0.12-0.45$).

DISCUSSION

The primary aim of this study was to assess the knowledge, attitudes, and practices regarding sustainable healthcare among undergraduate medical and dental students at a tertiary care college in Khyber Pakhtunkhwa, Pakistan. Our findings show that while students have moderate awareness of eco-friendly principles, a substantial gap remains between theoretical knowledge and practical implementation.

This study shows how our medical and dental students understand and apply eco-friendly practices in healthcare. Most students showed a particular level of awareness of biomedical waste management and energy-saving behaviours. Still, their attitudes did not fully match their knowledge, reflecting a gap between awareness and practice. These findings align with previous research conducted in other developing nations. For instance, Talukder and Hipel (2022) reported similar knowledge-practice disparities among healthcare workers in Bangladesh, while Vieira et al. (2009) documented comparable gaps in Brazilian dental settings^[6,13].

Our study shows that the majority of students (73%) have knowledge about hazardous waste and could identify it, but still 54% of them admitted that they threw waste in common bins. Similar findings appear in some studies^[13,17], showing either habitual non-compliance or deficiencies in facilities such as colour-coded bins. In a study by Tompe et al. (2020) across multiple Asian countries, the average knowledge-practice gap in biomedical waste management was reported at 28%, which closely mirrors our finding of 27%. Although most of the students (84%) agreed that colour coding for waste disposal is essential, only 69% of participants knew of colour coding highlights the risk of waste exposure.

Compared to international benchmarks, our participants demonstrated moderate competency. Walpole et al. (2015) found that UK medical students showed 82% awareness of sustainable healthcare principles, higher than our cohort's 73%. However, our results are comparable to studies from other low- and middle-income countries, where awareness levels typically range from 55-75%^[10].

As shown by Barros et al., fewer than 50% of students reported conservative practices, indicating a lack of sustainability in their clinical training^[18]. But still, 84% of the participants emphasized the inclusion of training in the curriculum, reflecting their eco-friendly awareness and a shift towards the vision of FDI and WHO of eco-friendly sustainability in the medical profession for a positive impact; yet in Pakistan, medical curriculum still need improvements to meet standards of the US and EU^[10,19]. Specifically, Bakhshi et al. (2023) noted that Pakistani medical curricula currently allocate less than 5% of total instructional hours to environmental health topics, compared to 12-15% in European medical schools^[20].

As 78% of students showed interest in further training inclusion in the curriculum, and 83% marked the importance of Hep B vaccinations, which shows their practical readiness, also seen in a study^[21]. In our study, dental students showed numerically higher waste management awareness than medical students, aligning with trends observed by Ahsen et al., who reported similar findings among dental students in Lahore, Pakistan^[14]. However, both groups demonstrated room for improvement. These findings are also consistent with a local study from Pakistan by Shaheen M et al. (2022), who reported that healthcare workers in Lahore demonstrated adequate knowledge but poor waste segregation practices^[22].

In summary, while students showed awareness of eco-friendly principles, they need major improvements to bridge the knowledge-practice gap. Strengthening curricula, improving campus infrastructure, and creating opportunities for practical application will be essential for shaping a more sustainable healthcare system.

LIMITATIONS:

There were a few limitations of the study, such as it being a single-centre study; representative participants were from one institute, having constituent medical and dental colleges were recruited, and hence deficiencies in broader perspectives of curriculum pan Pakistan could have reflected as a gap in knowledge of the participants. Therefore, findings cannot be generalized to all Pakistani medical and dental students beyond Khyber Pakhtunkhwa province. Furthermore, the non-inclusion of auxiliary staff, who are the driving force in ensuring eco-friendly practices, was a limitation, which also limits the wider impact of this study.

Specific Recommendations for Policy and Curriculum:

Based on the findings of this study, the following specific recommendations are proposed:

For Regulatory Bodies (Pakistan Medical & Dental Council - PMDC):

1. Mandate a minimum of 10 credit hours of "Sustainable Healthcare Practices" as a compulsory module across all MBBS and BDS programs nationwide.
2. Include questions on biomedical waste management, energy conservation, and recycling in the annual professional examinations (at least 5% of total marks in Community Medicine and Oral Health Sciences).

For the Ministry of Health, Pakistan:

3. Adopt ISO 14001 standards for environmental management in all teaching hospitals and dental clinics within two years.
4. Establish a national surveillance system to monitor healthcare waste segregation and disposal practices quarterly.

For Healthcare Institutions and Universities:

5. Install colour-coded waste bins with visual aids in all clinical areas and conduct monthly audits of waste segregation compliance.
6. Organize biannual hands-on training workshops on sustainable healthcare practices for all clinical-year students.

7. Implement motion-sensor lighting and energy-efficient equipment in all academic and clinical facilities by 2027.

For Curriculum Developers:

8. Integrate case-based learning modules on planetary health into existing subjects (Pathology, Pharmacology, Community Medicine, and Operative Dentistry).
9. Develop a standardized online learning resource on eco-friendly healthcare practices accessible to all medical and dental students in Pakistan.

CONCLUSION

This study adds to the growing body of local evidence on sustainable healthcare in Pakistan. In line with recommendations by the above studies, urgent curricular reforms are needed to bridge the knowledge-practice gap identified across multiple Pakistani institutions. Pakistani medical and dental students demonstrated a certain level of knowledge and awareness of eco-friendly practice concepts. However, they need interdisciplinary training programs in the medical curriculum to translate their knowledge into practice aligned with the SDGs^[9]. Timely and focused attention to curricular reforms could positively impact the healthcare system and our ecosystem.

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Authors Contributions:

Abdul Manan: Substantial contributions to the conception and design of the work.

Sadia Rashid: Acquisition of data for the work.

Muhammad Jehangir Khan Bhatti: Analysis and interpretation of the data.

Muhammad Adnan Iqbal: Drafting the work.

Syed Abir Hussain: Reviewing it critically for important intellectual content.

Muhammad Azhar: Final approval of the version to be published.