An Ergonomic Evaluation of Mosque Ablution Areas (Shadirvans): A User Perception Study

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Abstract.

Mosque ablution areas (shadirvans) play a critical role in supporting ritual purification; however, their design is largely unstandardized and rarely evaluated from an ergonomic perspective. This study investigates the effectiveness of existing shadirvan designs by assessing user perceptions of comfort, safety, hygiene, and usability. A questionnaire-based survey was administered through structured interviews with 200 male users across 15 mosques in Istanbul, Türkiye. Fourteen Likert-scale items were used to evaluate key design and functional aspects of shadirvans. Descriptive analyses and multivariate analyses of variance (ANOVA) were conducted to examine the effects of demographic factors and mosque-specific design characteristics on user perceptions. The results indicate that while shadirvans are generally preferred over alternative ablution solutions, their performance is inconsistent and often insufficient. Common problems were identified in footwear management, water splashing control, and the organization of wet and dry zones. Traditional features such as shared clogs were largely perceived as uncomfortable and unhygienic. Statistical analyses revealed that user perceptions were predominantly influenced by the mosque itself, rather than by demographic characteristics, highlighting the strong impact of design variability. These findings provide empirical evidence that the absence of standardized design guidelines leads to significant differences in usability and user satisfaction. The study underscores the need for evidence-based, user-centered design standards to improve comfort, hygiene, and safety in mosque ablution facilities.

Keywords: *Shadirvan; Mosque design; Ablution areas; Ergonomics and Design standardization.*

I. INTRODUCTION

The mosque is the primary religious space in Islam, serving as a place where Muslims gather to worship Allah and perform collective religious duties. Beyond its central role in congregational prayer, the mosque has historically functioned as a multifunctional institution, acting as a center for education, social interaction, welfare activities, and, in some contexts, governance and healthcare [1]. These diverse roles position the mosque not only as a religious structure but also as a focal point of Muslim community life.

Architecturally, mosque design aims to support spiritual reflection and communal worship. Elements such as spatial organization, interior scale, lighting, materials, and ornamentation are intentionally arranged to evoke a sense of serenity, humility, and unity [2]. The architectural program of a mosque must therefore respond to both functional requirements, particularly those related to prayer, and the symbolic values of Islam, including cleanliness, order, and universality [3, 4].Prayer (Salah) constitutes one of the fundamental obligations in Islam and is performed five times daily at prescribed times determined by the sun's position. While prayer may be conducted individually in any clean environment, congregational prayer is strongly encouraged and holds greater religious merit. This emphasis has direct implications for mosque design, including the need to accommodate large groups of worshippers, especially during the weekly Friday prayer, which is obligatory for adult males and typically attracts significantly higher attendance than daily prayers. Additionally, congregational prayer requires gender segregation, leading to spatial differentiation and controlled circulation within both prayer and ablution areas [5].

Ablution (Wudu') is a mandatory ritual purification performed prior to prayer. Rooted in Islam's strong emphasis on cleanliness, ablution represents both physical hygiene and spiritual preparedness. The ritual consists of washing specific body parts - namely the hands, mouth, nose, face, arms up to the elbows, head, ears, and feet - in a prescribed sequence using clean water. The state of ablution is nullified by certain everyday actions, such as using the toilet, sleeping, or loss of consciousness, necessitating its repetition before subsequent prayers.Due to its obligatory nature and frequent repetition, ablution constitutes a critical

functional activity within mosque use. Accordingly, every mosque is required to provide designated ablution facilities, typically located in close spatial relation to the main prayer hall. The physical characteristics, design quality, and usability of these spaces directly influence worshippers' comfort, safety, and efficiency in performing the ritual as poorly designed ablution areas may result in discomfort, safety risks, and hygiene problems [5].A fundamental requirement of ablution facilities is the provision of clean, continuously available water without imposing unnecessary physical effort on the user. In this context, water conservation also emerges as a key design concern as Islamic teachings emphasize moderation in water use. However, conventional faucets often result in excessive water consumption, leading to the adoption of water-saving technologies such as metered or sensor-activated taps, despite their higher cost and maintenance demands [5].

Ablution spaces, often referred to as shadirvans in traditional mosque architecture, must respond to ergonomic requirements to ensure safety, comfort, and accessibility. Ergonomic design is particularly important for elderly users and individuals with reduced mobility, for whom poorly designed ablution units can pose significant physical challenges [2]. Accordingly, the ablution unit may be conceptualized as an ergonomic workstation that must simultaneously satisfy religious, functional, and human-centered design criteria.From an ergonomic perspective, body posture during ablution is a primary consideration. Users should be able to perform all ritual actions without excessive bending of the back or knees, as awkward postures increase physical strain and the risk of musculoskeletal discomfort [6]. Faucet design and placement are equally critical. The faucet should be durable and positioned at a height that aligns with users' anthropometric characteristics, ideally relative to elbow height, to minimize bending. The distance between the user and the water outlet must also be carefully determined to reduce splashing while remaining reachable for users of different statures [7]. Since faucets are frequently used as informal support points, robustness is essential, and short-necked designs are often preferred [5].Adequate spacing between adjacent ablution points is necessary to allow free movement of the arms and legs without interference from neighboring users. Sufficient space is also required to enable users to lift one foot and maintain balance while washing it. Supportive elements such as handrails, seating surfaces, and small shelves can enhance stability and comfort, particularly for elderly users [2].Safety and hygiene constitute additional critical design dimensions.

The presence of water inherently increases the risk of slipping and falling, making floor material selection and drainage design crucial. Flooring should be slip-resistant and designed to facilitate rapid water runoff. Level changes and raised platforms, if unavoidable, must be carefully designed to minimize tripping and slipping hazards. Effective drainage systems are essential to prevent water accumulation, wastewater overflow, and unsanitary conditions. Poorly designed drainage and hard-to-clean surfaces can promote bacterial and fungal growth, negatively affecting user health and comfort [5].Although existing studies, such as those proposed by Mokhtar [5], provide important reference points for addressing ergonomic, safety, and hygiene considerations in mosque ablution spaces, universally accepted standards for ablution facility design remain limited. For example, in Türkiye, ablution areas vary considerably across mosques due to the absence of enforced design standards. To support the development of such standards, a clear understanding of user needs is essential. Accordingly, the primary aim of the present study is to examine the effectiveness of existing ablution areas (shadirvans) by assessing users' perceptions of key design and usability criteria through a questionnaire-based survey conducted among male mosque users in Türkiye.The remainder of this paper is organized as follows. The Materials and Methods section describes the study design, questionnaire structure, data collection process, and statistical analysis methods. The Results and Discussion section presents the quantitative findings and interprets them in relation to design effectiveness and usability considerations. Finally, the Conclusion section summarizes the main findings, discusses their implications for ablution area design, and outlines directions for future research.

II. METHODS

A. Study Design and Participants

This study employed a cross-sectional design to investigate users' perceptions of the design and usability of shadirvans. Data were collected over a two-month period between March and April, during which a questionnaire-based survey was administered in 15 different mosques located in Istanbul, Türkiye (see Fig. 1).

Fig 1. Examples of mosque ablution areas (shadirvans) where the questionnaire was administered.

A total of 200 male participants took part in the study. Participants were recruited using a convenience sampling approach, based on the accessibility of mosques to the interviewers and logistical feasibility. During mosque selection, attention was paid to include both relatively new and older mosques in order to capture variation in ablution area design. Participants were invited to participate on a voluntary basis within the mosque's ablution areas, either before or after their ablution ritual, depending on their availability and willingness.To ensure a focus on general design usability, participation was limited to self-reported healthy individuals, including the elderly. Users with physical disabilities were excluded to maintain response homogeneity, as specialized accessible facilities are beyond the current study's scope and reserved for future research.

Prior to participation, the interviewers explained the aim and scope of the study to all potential participants. Verbal informed consent was obtained, and only individuals who agreed voluntarily were included in the survey. To minimize respondent burden and ensure clarity, the questionnaire was administered through face-to-face interviews, during which the interviewers read each item aloud and recorded the participants' responses, rather than having participants complete the questionnaire themselves. No personal identifiers were collected, and responses were recorded anonymously.Demographic data, including age, height, weight, and frequency of mosque attendance, were collected to explore potential associations with user perceptions. Table 1 summarizes the descriptive statistics for these variables, including Body Mass Index (BMI).

Table 1. Demographic characteristics of the study participants (n = 200)

Variable	*Mean*	*SD*	*Min*	*Max*
Age	34.8	14.5	15	77
Height	174.8	6.5	155	193
Weight	79.0	11.1	55	130
BMI	25.9	3.8	18	44

B. Questionnaire

Data were collected using a structured questionnaire developed specifically for this study to assess users' perceptions of the design and usability of mosque ablution areas. The questionnaire was designed

based on relevant literature on ablution space design and ergonomic considerations, and aimed to capture users' evaluations of distinct physical and functional features of shadirvans.The instrument consisted of 14 closed-ended items (see Table 2), each addressing a specific aspect of shadirvan use, including overall comfort, convenience in handling personal belongings, water splash and cleanliness, seating ergonomics, footwear-related features, and the availability of supporting facilities such as paper towels and hot water. Responses were recorded using a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

The questionnaire was not intended as a standardized or validated scale, and therefore no composite score was calculated. Instead, each item was treated as an independent measure reflecting a distinct design-related or ergonomic issue. This approach was adopted to allow a detailed evaluation of individual design features and to facilitate the identification of specific aspects perceived as effective or problematic by users.
In addition to the perception-based items, the questionnaire collected demographic and contextual information, including age, height, weight, frequency of mosque use (rarely, sometimes, often), and the specific mosque where the ablution facility was used. These variables were used to examine potential associations between user characteristics, mosque-specific design differences, and perceived usability of shadirvans.

C. Statistical Analysis

Statistical analyses were conducted to examine users' perceptions of shadirvan design and to identify factors influencing responses to each questionnaire item. Initially, descriptive statistics were calculated for all questionnaire items. For each question, the percentage distribution of responses across the five Likert-scale categories (1 = strongly disagree to 5 = strongly agree) was determined. In addition, the proportion of respondents who expressed agreement with each statement was calculated by combining responses of agree (4) and strongly agree (5).To investigate the effects of user characteristics and design-related factors on perceptions of shadirvan usability, multivariate analysis of variance (ANOVA) was performed separately for each of the 14 questionnaire items. The dependent variable in each analysis was the Likert-scale response to the corresponding item. The independent variables included age group, height category, body mass index (BMI) category, frequency of mosque use, and mosque, the latter representing differences in ablution area design.

All continuous variables were categorized prior to analysis to meet the assumptions of ANOVA and to facilitate interpretation. Age was classified into three groups: youth (≤24 years), adults (25-64 years), and seniors (≥65 years). Height was categorized into short, medium, and tall groups based on Turkish anthropometric reference data [8], where individuals shorter than one standard deviation below the national mean height (1708 mm - 81 mm) were classified as short, and those taller than one standard deviation above the mean (1708 mm + 81 mm) were classified as tall; all others were classified as medium. BMI categories were defined according to the World Health Organization criteria [9]: underweight (<18.5 kg/m²), normal weight (18.5 - 24.9 kg/m²), overweight (25.0 - 29.9 kg/m²), and obese (≥30.0 kg/m²). Frequency of mosque use was categorized into three levels: rarely, sometimes, and often.For each questionnaire item, the multivariate ANOVA was used to identify statistically significant independent variables at a significance level of $p < 0.05$. Following this step, a secondary ANOVA model was constructed for each item, including only the variables found to be statistically significant in the initial analysis. This two-stage approach was adopted to isolate the dominant factors affecting user perceptions while reducing model complexity.All statistical analyses were performed using Minitab statistical software, and a significance level of $p < 0.05$ was adopted throughout the study.

III. RESULT AND DISCUSSION

Table 2 presents the distribution of responses to the shadirvan user perception questionnaire and for ease of interpretation, it also reports the percentage of participants who agreed with each statement, calculated as the sum of 'agree' and 'strongly agree' responses. Overall, the findings reveal moderate levels of satisfaction, accompanied by substantial variability across design-related dimensions, indicating that current shadirvan designs only partially meet user needs.

Table 2. Percentage distribution of responses and agreement levels for shadirvan user perception items.

Ablution Fountain (*Shadirvan*) User Perception Questionnaire						
	1 (Strongly disagree)	2 (Disagree)	3 (Neutral)	4 (Agree)	5 (Strongly agree)	Agree / Strongly agree (%)
A. Overall Comfort and Preference						
1. I can perform ablution comfortably at the shadirvans.	6.5	22.5	11.5	40.5	19.0	59.5
2. I find performing ablution at shadirvans more comfortable than performing it at regular washbasins.	9.0	17.0	7.5	41.0	25.5	66.5
B. Clothing, Personal Items, and Convenience						
3. I can find a suitable place to hang my jacket or coat while performing ablution.	3.0	11.0	12.0	50.5	23.5	74.0
4. I can find a place to put my socks and shoes after removing them during ablution.	19.0	35.0	8.0	29.0	9.0	38.0
5. I can easily put on and take off my socks and shoes while performing ablution at the shadirvans.	9.5	27.5	12.0	40.5	10.5	51.0
C. Environmental Control and Seating Ergonomics						
6. Water does not splash onto my clothes while I am performing ablution at the shadirvans.	17.5	29.5	13.5	30.5	9.0	39.5
7. I find the height of the seats used during ablution comfortable.	8.0	16.0	13.0	50.0	13.0	63.0
8. I find the distance between the seats and the water taps appropriate.	5.5	17.0	13.5	50.0	14.0	64.0
9. I find the width of the seats sufficient.	3.5	13.0	7.0	58.5	18.0	76.5
10. I find the stability of the seats comfortable and safe for performing ablution.	1.5	13.5	13.0	54.0	18.0	72.0
D. Footwear and Hygiene Accessories						
11. I prefer using provided clogs rather than regular shoes while performing ablution at the shadirvans.	21.0	32.0	8.0	25.5	13.5	39.0
12. I find the clogs provided at the shadirvans comfortable and hygienic.	32.0	34.0	13.5	15.0	5.5	20.5
E. Supporting Facilities						
13. I consider the availability of paper towels at the shadirvans important.	3.0	6.5	2.0	25.0	63.5	88.5
14. I consider the availability of hot water at the shadirvans important.	2.0	6.0	6.0	33.0	53.0	86.0

With respect to general usability, 59.5% of participants reported that they could perform ablution comfortably at shadirvans, while 66.5% found shadirvans more comfortable than performing ablution at regular washbasins. Although these results indicate a general preference for shadirvans as a concept, the absence of stronger consensus suggests that comfort levels are not consistently achieved across mosques. The presence of considerable neutral and negative responses points to differences in design quality rather than inherent inadequacy of the ablution fountain typology itself.Responses related to the handling of personal items demonstrate a clear imbalance between upper-body and lower-body needs. While a large majority of participants (74.0%) indicated that they could find a suitable place to hang jackets or coats, significantly lower agreement levels were observed for footwear-related actions. Only 38.0% reported being able to find an appropriate place to put socks and shoes, and 51.0% indicated that they could easily put on and take off footwear during ablution. These findings suggest that most shadirvans provide basic provisions for hanging clothing, yet fail to adequately support the critical transition from shoe-wearing to barefoot conditions. In many existing designs, users are left uncertain about where to place their shoes and how to stand or move barefoot without stepping on wet or unhygienic surfaces.

The lack of clearly defined dry zones and shoe storage areas disrupts the ablution sequence and negatively affects perceived convenience and hygiene.Water splashing emerged as one of the most problematic aspects of shadirvan use. Only 39.5% of respondents agreed that water does not splash onto their clothes during ablution, while a substantial proportion expressed disagreement. This finding indicates a systemic design issue, likely related to inappropriate tap height, insufficient distance between the user and

water outlet, inadequate drainage design, or poor separation of wet and dry areas. Excessive splashing not only causes discomfort but also contributes to wet clothing, slippery surfaces, and reduced hygiene, all of which negatively affect user experience. The persistence of this issue across responses suggests that water control is insufficiently considered in many existing shadirvan designs.Perceptions of seating-related features showed mixed results. Structural characteristics such as seat width (76.5% agreement) and stability (72.0%) were generally evaluated positively, indicating that these aspects are relatively well addressed. In contrast, spatial and anthropometric parameters, namely seat height (63.0%) and distance between seats and water taps (64.0%), received only moderate agreement.

This pattern suggests that while designers may prioritize basic dimensions, anthropometric relationships and reach requirements are less consistently addressed. Inadequate seat height and improper tap distance may force users into awkward postures, increasing physical strain, particularly for elderly users. These findings reinforce the importance of incorporating anthropometric data into shadirvan design to ensure comfortable and safe postures during ablution.The results related to the use of traditional clogs provided in the shadirvans indicate low acceptance. Only 39.0% of participants preferred clogs over regular shoes, and a mere 20.5% found them comfortable and hygienic. These findings suggest that shared footwear is largely perceived as uncomfortable or unhygienic, potentially due to maintenance conditions, material properties, or changing user expectations. This outcome highlights a disconnect between traditional design elements and contemporary user perceptions, suggesting that certain long-standing features of shadirvans may require reconsideration or redesign to align with current hygiene expectations.In contrast to several design shortcomings, there was strong consensus regarding the importance of supporting facilities. The availability of paper towels (88.5%) and hot water (86.0%) received the highest agreement levels among all items. These results indicate that users place considerable importance on post-ablution comfort, drying, and thermal comfort. Given their relatively low implementation cost, the consistent prioritization of these features underscores missed opportunities in many existing shadirvan designs and further reflects the absence of standardized design guidelines.

Multivariate ANOVA results revealed that only 10 of the 14 questionnaire items were significantly affected by at least one independent variable. For four items (Q3, Q9, Q10, and Q14), no statistically significant effects were observed, indicating that user perceptions related to these aspects were relatively consistent across participants and mosque contexts.For the remaining items, a notable and consistent pattern emerged: only one significant factor was identified for each question, and this factor was overwhelmingly the mosque itself, representing differences in ablution area design. Specifically, mosque was the sole significant factor for Questions 1, 2, 4, 5, 6, 7, 8, 11, and 12 (see Table 3). Demographic variables such as age, body mass index, frequency of mosque use, and height did not demonstrate a meaningful influence on responses for these items.This finding provides strong empirical support for the argument that user perceptions of shadirvan usability are primarily shaped by design characteristics rather than by individual user attributes.

The fact that responses vary significantly across mosques but not across demographic groups suggests that the observed dissatisfaction and variability are rooted in non-standardized design practices, rather than differences in physical capability or usage habits. Importantly, this pattern reinforces the results presented in Table 2, where moderate agreement levels and substantial variability were observed across nearly all design dimensions.An exception to this dominant trend was observed for Question 13, which addressed the perceived importance of paper towel availability. In this case, height category emerged as the only significant factor. Shorter participants showed notably lower agreement (fitted mean = 2.8) compared to medium and tall participants (fitted means = 4.4). While this result reached statistical significance, it should be interpreted with caution, as the number of participants classified as short was limited. The finding may reflect a chance effect rather than a robust ergonomic relationship, particularly given the absence of similar demographic effects across other questionnaire items. Nevertheless, it is possible that taller users perceive drying facilities as more important due to greater exposure to water splashing or differences in reach and posture during ablution, a hypothesis that may warrant further investigation in studies with more balanced anthropometric representation.

Table 3. Summary of significant ANOVA results for questionnaire items.

	R^2 (%)	Significant Factor	p-value	minimum fitted mean	maximum fitted mean	range of fitted means
Q1	23.7	Mosque	> 0.01	2.45	4.15	1.70
Q2	12.6	Mosque	> 0.01	2.80	4.30	1.50
Q4	12.2	Mosque	> 0.01	1.85	3.40	1.55
Q5	14.4	Mosque	> 0.01	2.20	3.80	1.60
Q6	10.6	Mosque	0.02	2.00	3.55	1.55
Q7	14.4	Mosque	> 0.01	2.40	3.85	1.45
Q8	24.9	Mosque	> 0.01	2.55	4.20	1.65
Q11	17.2	Mosque	> 0.01	1.30	3.95	2.65
Q12	15.6	Mosque	> 0.01	1.30	2.95	1.65
Q13	6.4	Height	> 0.01	2.80	4.44	1.64

Note: Only questionnaire items with at least one statistically significant factor ($p<0.05$) are reported. For each item, only one significant factor was identified. Fitted means refer to estimated means from the ANOVA models.

The explained variance values (R^2), which ranged from 6.4% to 24.9%, indicate that while mosque design does not account for all variability in user responses, it represents a meaningful and consistent determinant of user perception across multiple usability dimensions.Overall, the ANOVA results clearly demonstrate that the absence of enforced design standards leads to measurable differences in user satisfaction and perceived effectiveness of ablution facilities. Rather than pointing to isolated design flaws in individual mosques, these findings highlight a systemic issue: when ablution areas are designed independently without reference to shared ergonomic and functional criteria, user experience becomes highly dependent on the specific mosque.

This reinforces the need for evidence-based, standardized design guidelines for shadirvans that prioritize usability, safety, and hygiene.Taken together, the results demonstrate that current shadirvan designs provide only partial support for effective and comfortable ablution. While some structural elements perform adequately, critical issues related to footwear management, water control, anthropometric fit, and hygiene remain unresolved. The variability observed across items supports the conclusion that design differences between mosques, rather than user demographics, are the dominant factor influencing user perceptions, reinforcing the need for standardized, user-centered design criteria for ablution spaces.

IV. CONCLUSION

This study evaluated the effectiveness of shadirvans by examining users' perceptions of key design and usability criteria through a questionnaire-based survey conducted in 15 mosques in Istanbul. Although shadirvans were generally preferred over alternative ablution solutions, the findings indicate that their performance is inconsistent and often inadequate. Moderate agreement levels across most items reveal that current designs only partially support the ablution process, with notable shortcomings in footwear management, control of water splashing, and the organization of wet and dry zones, all of which negatively affect comfort and hygiene.

Traditional design elements such as shared clogs were also largely perceived as uncomfortable and unhygienic, highlighting a mismatch between conventional practices and contemporary user expectations.Statistical analyses further showed that user perceptions were primarily influenced by the mosque itself rather than by demographic characteristics, demonstrating that variability in satisfaction is mainly driven by design differences resulting from the absence of standardized design principles.Overall, the findings emphasize the need for evidence-based, user-centered design standards for shadirvans. Future research should focus on translating user feedback into standardized ergonomic design criteria and testing their effectiveness across diverse user groups to improve safety, hygiene, and user satisfaction in mosque ablution spaces.

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REFERENCES

[1] J. A. Rahman, Z. Kamarudin, M. H. Abdullah, I. Jasmani, and N. Ramli, "Physical and safety features of ablution spaces in the mosques of Selangor and Kuala Lumpur," IOP Conference Series: Materials Science and Engineering, vol. 401, no. 1, p. 012020, Sep. 2018.

[2] S. A. C. Hasbi and S. Hamat, "The ergonomics of the Islamic ablution: exploring considerations for the elderly in the mosque," Cultural Syndrome, vol. 2, no. 1, pp. 59–77, 2020.

[3] Ş. E. Okuyucu, "Evaluation of spatial fictions, design concepts, aesthetic quests of traditional, modern mosques from past to present and the analysis of mosque samples," Civil Engineering and Architecture, vol. 4, no. 2, pp. 54–66, 2016.

[4] N. Çevik, "A comparative study on the architectural and symbolic values of Masjid al-Haram and Masjid an-Nabawi," Tasavvur / Tekirdağ İlahiyat Dergisi, vol. 11, no. 1, pp. 333–369, 2025.

[5] Mokhtar, Design guidelines for ablution spaces in mosques and Islamic praying facilities, Master's thesis, American University of Sharjah, Sharjah, UAE, 2005.

[6] J. Barthelme, M. Sauter, C. Mueller, and F. Liebers, "Association between working in awkward postures, in particular overhead work, and pain in the shoulder region in the context of the 2018 BIBB/BAuA Employment Survey," BMC Musculoskeletal Disorders, vol. 22, no. 1, p. 624, 2021.

[7] A. Abd Ghani, E. H. Sukadarin, and N. M. Nawi, "Investigation on the ergonomics design of Wudhu' (ablution) station at a mosque in a higher learning institution," Current Science and Technology, vol. 1, no. 1, pp. 15–25, 2021.

[8] Iseri and N. Arslan, "Estimated anthropometric measurements of Turkish adults and effects of age and geographical regions," ***International Journal of Industrial Ergonomics, vol. 39***, no. 5, pp. 860–865, 2009.

[9] World Health Organization, Physical status: The use and interpretation of anthropometry, WHO Expert Committee, WHO Technical Report Series no. 854, Geneva, Switzerland, 1995.