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# Reliability and Validity of an Adapted Questionnaire Assessing Occupational Exposures to Hazardous Chemicals among Health Care Workers in Bhutan

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## Abstract

**Background:** Collection of reliable and valid occupational history data is of utmost importance to assess work-related exposures and their health effects. Few standardized questionnaires are available for the collection of occupational history data in low-and-middle income countries.

**Objective:** To adapt and test a validated questionnaire developed in the United States by the National Institute of Safety and Health, in order to assess occupational chemical exposures among health care workers in Bhutan.

**Methods:** The questionnaire was first adapted to suit the Bhutanese context with the advice of an expert review committee. 30 health care workers then completed the questionnaire at baseline and 10–14 days later. Test-retest reliability was assessed by calculating Cohen's  $\kappa$  and percentage agreement.

**Results:** The questionnaire had high test-retest reliability. Cohen's  $\kappa$  ranged from 0.61 to 1.00, and percentage agreement ranged from 86.7% to 100%. Further adaptations included omitting questions on chemicals not available in Bhutan.

**Conclusion:** The adapted questionnaire is appropriate for assessing occupational chemical exposures among health care workers in Bhutan.

**Keywords:** Occupational exposure; Health personnel; Surveys and questionnaires; Advisory committees; Developing countries; Bhutan

## Introduction

Health care workers (HCWs) operate in an environment containing numerous hazards that pose daily risks to their health.<sup>1</sup> The health care sec-

tor has consistently reported a high prevalence of non-fatal injuries and illnesses in the USA, and Australia.<sup>2,3</sup> With a worldwide population of 56 million HCWs, the health care sector employs 13% of the global workforce.<sup>4</sup> Job growth in this industry

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is expected to increase to meet the rising needs of an aging global population. A substantial population of HCWs will therefore be at risk of harm in the workplace, with the potential to adversely impact the quality of health care services.

Occupational exposures to biological and psychological hazards among HCWs are widely recognized.<sup>5</sup> Less apparent is that the health care environment also contains hazardous chemicals similar to those found in “blue-collar” industries, exposures to which can increase the risk of long-term adverse health outcomes. Exposures to chemicals such as ethylene oxide, formaldehyde, and antineoplastic drugs have been linked to certain types of cancers such as hematological and nasopharyngeal cancers.<sup>6-8</sup> Exposure to latex as well as a number of chemicals in cleaning and disinfecting agents have been associated with work-related asthma among HCWs.<sup>9,10</sup> Chemicals used in hospital laboratories such as toluene, styrene, and xylene have the potential to cause auditory damage and hearing loss.<sup>11</sup>

Research on occupational exposures to hazardous chemicals among HCWs has highlighted these risks, and safety programs and standards have been instituted to ensure the safety of these workers.<sup>12</sup> However, the majority of these studies have been conducted in high-income countries.<sup>5</sup> Very little work has been done on examining these hazards in low- and middle-income countries (LMICs).<sup>13</sup> The limited research in this area from LMICs has mainly examined exposure to latex.<sup>14</sup>

The collection of valid and reliable occupational history data is of utmost importance in estimating occupational exposures and work-related health effects. One way of obtaining this information is through questionnaires, which can collect details to assist in exposure assessment (*eg*, tasks conducted within a job, and use of control measures).<sup>15</sup> Unfortunately,

there are very few standardized questionnaires available in this area,<sup>16</sup> especially so for use in LMICs.

The National Institute for Occupational Safety and Health (NIOSH) developed a questionnaire for the Health and Safety Practices Survey of HCWs conducted in the USA in 2011, which aimed to examine safety practices to minimize exposure to hazardous chemicals in the workplace.<sup>17</sup> The questionnaire used in the survey may not be directly applicable for use in LMICs due to differences in legislation, work environments, and safety standards. The objective of this study was therefore to adapt and test this questionnaire for use in Bhutan to assess occupational exposures to asthmagens, carcinogens, and ototoxic chemicals among HCWs.

## Materials and Methods

This study was conducted in two stages: (1) the adaptation of the NIOSH questionnaire, and (2) test-retest reliability assessment.

### Stage 1: Adaptation of the NIOSH Questionnaire

The NIOSH questionnaire was developed for a Web-based survey of HCWs to examine safety practices to minimize exposure to chemicals in the workplace.<sup>17</sup> The survey instrument contains seven hazard modules and a core module. The core module includes questions about demographics and exposures to other occupational hazards (*eg*, infectious agents). The hazard modules contain questions about frequency and duration of exposures, and work practices and control measures used to minimize exposure to chemicals that are commonly encountered in the health care setting (*ie*, anaesthetic drugs, aerosolized medications, antineoplastic drugs, chemical sterilants, high-level disinfectants, and surgical smoke).

A committee of experts in Bhutan was consulted during the process of questionnaire adaptation. The committee of experts comprised of two senior doctors and a nurse with extensive practical experience within the Bhutanese health care system, and one nurse specialized in occupational health. The NIOSH questionnaire was developed for a high-income country with advanced medical technology and drugs, many of which are not available in Bhutan. The committee was asked whether to retain each question in the instrument to make the questionnaire appropriate for the Bhutanese context. For example, the module on high-level disinfectants in the original questionnaire included questions on the use of manual or automated disinfection systems. The questions on automated disinfection systems were excluded because they were not used in Bhutan. Since the original questionnaire did not include chemicals used in laboratories, dental departments, and for cleaning, questions on these chemicals were adapted from the health care job module in OccIDEAS, a computer application that assesses occupational exposures.<sup>18</sup> OccIDEAS consists of job modules that include questions about various tasks carried out in a particular job, and about control measures that might influence exposure levels. These modules are developed based on evi-

dence from literature and expert opinion.

The pre-final version of the modified questionnaire was then reviewed by the experts to assess the validity of the instrument. The experts evaluated whether the items in the questionnaire were relevant to the Bhutanese context, whether the questions were comprehensible to Bhutanese HCWs, and determined the comprehensiveness of the questionnaire. The experts felt that the hard-copy version of the questionnaire would be more acceptable to the population. Based on the experts' review, the final version of the modified questionnaire was consolidated for testing as a hard-copy version in English. Tertiary education in Bhutan is delivered in English,<sup>19</sup> so health professionals have no difficulty with an English-language questionnaire. Questions about the survey instrument (comprehensibility, ease of use, and preferred mode of administration) were also included in the final version to obtain additional feedback from participants.

### Questionnaire

Sociodemographic variables such as age, sex, ethnicity, and level of education were collected. For occupational history, participants were asked about the hospital and department they were currently working in, their job title, and the duration of employment as a HCW. Participants were also asked about the tasks that were carried out as part of their job (*eg*, sterilizing instruments, working in the dental department, laboratory or surgery, preparing drugs, suturing, cleaning the workplace, administering antineoplastic drugs and anesthetic gases), and about current work practices and control measures to minimize exposures to chemicals (*eg*, using portable smoke evacuators to remove smoke during diathermy, fume hoods in the laboratory, waste gas scavenging systems to remove waste anesthetic gases, biological safety cabinets while compounding antineoplas-

For the Questionnaire see the Web extra on the Journal Web site

### TAKE-HOME MESSAGE

- Few standardized questionnaires are available to collect occupational history data in low- and middle-income countries (LMICs).
- A questionnaire adapted for use in Bhutan showed good reliability and validity in assessing occupational chemical exposures in health care workers.
- The process of questionnaire adaptation and testing used in this study could assist in developing questionnaires for other LMICs.

**Table 1:** The list of asthmagens, carcinogens, and ototoxic chemicals assessed in a reliability study in Bhutan

Asthmagens	Carcinogens	Ototoxic chemicals
Acids	Industrial chemicals	Toluene
Ammoniacal compounds	Diethyl/dimethyl sulphate	Styrene
Asthma aldehydes	Epichlorhydrin	p-Xylene
Acrylates	Ethylene oxide	Trichloroethylene
Drugs	Formaldehyde	Ethyl-benzene
Epoxy	Ortho-toluidine	n-Hexane
Industrial cleaning and sterilizing agents		
Latex	Solvents	
Reactive dyes	Alcohol	
Other reactive chemicals	Aliphatic Solvents	
	Benzene	
	Chlorinated Solvents	
	Tetrachloroethylene (Perc)	
	Trichloroethylene	
	Products of combustion	
	Polycyclic aromatic hydrocarbons (PAH)	

tic drugs, and using gloves, water-resistant gowns, masks, and goggles while handling chemicals).

### Stage 2: Test-retest Reliability

#### Participants and Procedure

A targeted convenience sample of 30 HCWs was recruited from three hospitals (a tertiary hospital in Thimphu, and two district hospitals in Wangdue and Paro) located in the western region of Bhutan in April and May, 2019. The state provides free health care services to all citizens as mandated in the Constitution of Bhutan.<sup>19</sup> Therefore, all health care facilities in the country are in the public sector and all health care professionals work in these facilities. The western region of Bhutan has the highest number of HCWs as compared to the eastern and central regions, and half of the hospitals are located in this region.<sup>19</sup>

The eligibility criteria for the study were HCWs who were 18–60 years of age, and currently working in any one of the three hospitals included in the study. Care was taken to include participants from different

age groups, varying durations of employment, a range of job titles, and equal sex representation during the recruitment process.

Participants completed the questionnaire at two times—once at baseline (Time 1) and then 10–14 days later (Time 2). This time interval is considered adequate to provide independent observations and to prevent true variations in exposure.<sup>16</sup> Hard-copy questionnaires were personally distributed among the participants and collected when completed. All the questionnaires were self-administered, except for one participant (a hospital cleaner) who completed the questionnaire as an interview conducted in the local language.

#### Exposure assessment

The data from the questionnaire were entered into OccIDEAS. Based on the participants' responses in the questionnaire, pre-determined algorithms were applied in OccIDEAS to determine exposure to various carcinogens, asthmagens, and ototoxic chemicals (Table 1).<sup>18</sup> The rules in the algorithms were based on evidence from

**Table 2:** Frequency distribution of demographic characteristics of the sample of health care workers studied

Parameter	n (%)
<b>Sex</b>	
Male	14 (47)
Female	16 (53)
<b>Ethnic group</b>	
Ngalop	5 (17)
Sharshop	12 (40)
Lotshamp	10 (33)
Others	3 (10)
<b>Education</b>	
Primary/High school	4 (13)
Diploma	6 (20)
Bachelor's degree	11 (37)
Postgraduate degree	9 (30)
<b>Hospital</b>	
National Referral hospital, Thimphu	20 (67)
Paro hospital	5 (17)
Wangdue hospital	5 (17)
<b>Current occupation</b>	
Medical doctor	1 (3)
Dental doctor	3 (10)
Nurse	21 (70)
Technologist/technician and support staff	5 (17)
<b>Duration of work as health care worker (yrs)</b>	
<6	8 (27)
6–10	6 (20)
11–20	8 (27)
>21	8 (28)

literature, material safety data sheets, and expert advice from occupational hygienists on the determinants of exposures.

### Feed-back on the questionnaire

Participants were asked whether they had difficulties in using the questionnaire and in understanding the questions, and to provide reasons, if so. They were also asked to choose their preferred mode of questionnaire administration (hard-copy or Web-based).

### Ethics

Informed written consent was obtained from all participants. The study was approved by the Research Ethics Board of Health, Bhutan, and the Human Research Ethics Committee, Curtin University.

### Statistical Analysis

Statistical analyses were carried out using STATA 14 (StataCorp, College Station, TX). Descriptive statistics such as means and frequencies were estimated for sociodemographic variables. Cohen's  $\kappa$  (2 levels) and weighted  $\kappa$  (>2 levels) statistics, and percentages of overall agreement were used to test the reliability of the questionnaire. These were calculated for the questions related to the main tasks (yes/no), for exposures to chemicals (exposed/unexposed), and for specific tasks questions if there were enough responses. Established cut-off values for  $\kappa$  (ie, “poor” 0.00–0.20, “fair” 0.21–0.40, “moderate” 0.41–0.60, “strong” 0.61–0.80, and “almost perfect” agreement 0.81–1.00) and percentages of agreement ( $\geq 75\%$  was considered “acceptable”) were used to determine the adequacy of agreement of the estimates.<sup>20</sup>

## Results

### Adaptation of the Questionnaire

On advice from the experts, questions on chemicals used in the laboratory, the dental department, and in cleaning, were

**Table 3:** Test-retest reliability of the questions regarding the main tasks and exposure assessment in health care workers in Bhutan

Main tasks	n (%) answered yes		2×2				Cohen's $\kappa$ (95% CI)	% agreement
	Time 1	Time 2	YY <sup>a</sup>	YN <sup>b</sup>	NY <sup>c</sup>	NN <sup>d</sup>		
Do you sterilize instruments or other equipment yourself?	4 (13)	2 (7)	2	2	0	26	0.63 (0.19 to 1.00)	93
Do you work in the dental department?	3 (10)	3 (10)	3	0	0	27	1.00	100
Do you work in the pharmacy department?	0 (0)	0 (0)	—	—	—	—	—	—
Do you work in the laboratory	3 (10)	3 (10)	3	0	0	27	1.00	100
Do you perform sutures?	11 (37)	11 (37)	9	2	2	17	0.71 (0.45 to 0.97)	87
Do you work in surgery?	3 (10)	2 (7)	1	2	1	26	0.35 (-0.22 to 0.92)	90
Do you administer antineoplastic drugs?	1 (3)	1 (3)	1	0	0	29	1.00	100
Do you compound antineoplastic drugs?	0 (0)	0 (0)	—	—	—	—	—	—
Do you wear gloves at work?	30 (100)	30 (100)	—	—	—	—	—	—
Is one of your tasks to clean the work place?	18 (60)	17 (57)	17	1	0	12	0.93 (0.80 to 1.00)	97
Do you administer anaesthetic gases to patients?	2 (7)	2 (7)	2	0	0	2	1.00	100
<b>Exposures</b>								
<i>Asthmagens</i>								
Industrial cleaning and sterilizing agents	26 (87)	25 (83)	24	2	1	3	0.61 (0.21 to 1.00)	90
Ammoniacal compounds	10 (33)	10 (33)	9	1	1	19	0.85 (0.65 to 1.00)	93
<i>Ototoxic agents</i>								
P-xylene	12 (40)	11 (37)	10	2	1	17	0.79 (0.56 to 1.00)	90
Toluene	11 (37)	11 (37)	9	2	2	17	0.71 (0.45 to 0.97)	87
<i>Carcinogens</i>								
Aliphatic solvents	11 (37)	11 (37)	9	2	2	17	0.71 (0.45 to 0.97)	87

<sup>a</sup>Yes/Yes; <sup>b</sup>Yes/No; <sup>c</sup>No/Yes; <sup>d</sup>No/No

retained in the questionnaire. Questions on some chemicals (ethylene oxide, and hydrogen peroxide gas plasma), drugs

(aerosolized medicines), and control measures (use of purifying respirators with chemical cartridges, environmental expo-

**Table 4:** Test-retest reliability of questions on cleaning in Bhutanese health care workers

Question	n (%)		Weighted Cohen's $\kappa$ (95% CI)	% agree- ment
	Time 1	Time 2		
Use bleach for cleaning				
Yes	17 (57)	15 (50)	0.90 (0.89 to 0.93)	95
No	1 (3)	2 (7)		
NA*	12 (40)	13 (43)		
Use chlorhexidine for cleaning				
Yes	8 (27)	10 (33)	0.82 (0.54 to 0.86)	92
No	10 (33)	7 (23)		
NA*	12 (40)	13 (43)		
Use disinfectants for cleaning				
Yes	9 (30)	9 (30)	0.82 (0.78 to 0.93)	92
No	9 (30)	8 (27)		
NA*	12 (40)	13 (43)		
Use spirits for cleaning				
Yes	11 (37)	11 (37)	0.84 (0.74 to 0.89)	92
No	7 (23)	6 (20)		
NA*	12 (40)	13 (43)		
Wear gloves when handling cleaning agents				
Always	12 (40)	13 (43)	0.80 (0.76 to 1.00)	90
Sometimes	6 (20)	4 (13)		
Never	0 (0)	0 (0)		
NA*	12 (40)	13 (43)		
Wear goggles when handling cleaning agents				
Always	1 (3)	0 (0)	0.83 (0.72 to 0.90)	94
Sometimes	7 (23)	11 (37)		
Never	10 (33)	6 (20)		
NA*	12 (40)	13 (43)		

*Continued*

**Table 4:** Test-retest reliability of questions on cleaning in Bhutanese health care workers

Question	n (%)		Weighted Cohen's $\kappa$ (95% CI)	% agree- ment
	Time 1	Time 2		
Type of mask used when handling cleaning agents				
Standard surgical mask	17 (57)	17 (57)	0.90 (0.82 to 1.00)	95
N95 respirator	0 (0)	0 (0)		
Do not wear mask/respirators	1 (3)	0 (0)		
NA*	12 (40)	13 (43)		
Training received for handling cleaning agents				
Within past 12 months	3 (10)	4 (13)	0.85 (0.80 to 0.88)	94
More than 12 months	5 (17)	5 (17)		
Never received training	10 (33)	8 (27)		
NA*	12 (40)	13 (43)		

\*NA: not applicable, did not answer the cleaning questions

sure monitoring, and medical surveillance) were omitted because these were not available in Bhutan. The experts agreed that the adapted questionnaire was comprehensible and comprehensive.

### Sample Characteristics

The mean age of participants was 37.5 (SD 8.1, range 24 to 52) years; 53% were female (Table 2). Two-thirds (67%) of the sample reported having a university degree as their highest level of education. A majority of participants (70%) were nurses and two-thirds (67%) of the participants worked in the National Referral Hospital in Thimphu.

### Test-retest reliability

The percentages of overall agreement on questions regarding the main tasks carried out between Time 1 and Time 2 were excellent (87%–100%, Table 3). All  $\kappa$  estimates also demonstrated strong or almost perfect agreement (0.63–1.00) on the main

tasks carried out, except for the question on surgery which showed fair agreement ( $\kappa$  0.35).

Participants were exposed to at least one chemical from each of the three categories (carcinogens, asthmagens, and ototoxic agents) of hazardous chemicals assessed (Table 3). The prevalence of exposure to industrial cleaning and sterilizing agents was substantial at both Time 1 (87%) and Time 2 (83%). The percentages of overall agreement on the prevalence of exposures at Time 1 and Time 2 were excellent (87%–93%). The  $\kappa$  estimates also demonstrated strong to almost perfect agreement (0.61–0.85).

The task of cleaning the workplace was reported by almost two-thirds (57%–60%) of the participants (Table 4). The additional questions on cleaning asking about the use of cleaning chemicals, use of personal protective equipment, and training received on handling cleaning agents, showed a high degree of agree-



ment between Time 1 and Time 2. All the  $\kappa$  estimates demonstrated almost perfect agreement (0.80–0.90); the percentages of overall agreement were excellent (90%–95%). Reliability tests were not conducted for the additional questions on the other main tasks due to the low number of responses to these questions.

### Feed-back on the Questionnaire from the Participants

A majority of the participants (83%) chose hard-copy as their preferred mode of questionnaire administration. Four (13%) participants reported difficulties in using the questionnaire. One reported the questionnaire was too long and three participants said they found it tedious looking for the next questions after the skip questions (*ie*, if they answered no to the main question regarding a task, they skipped all the subsequent questions on that task and went on to the next main question). Only one participant reported difficulty in understanding the questions. The difficulty reported was on the question asking about whether they worked in surgery. The participant found this confusing as “do you work in surgery?” could mean either operating theatre, surgical ward, or minor surgery.

### Discussion

The objective of this study was to adapt and test a validated questionnaire to examine occupational exposures to hazardous chemicals among HCWs in Bhutan since standardized questionnaires suitable for use in LMICs are currently not available. This was achieved by modifying the questionnaire to make it relevant to Bhutan, followed by validation and reliability testing. The adapted questionnaire exhibited good content validity and strong to almost perfect test-retest reliability.

The modification of the questionnaire mainly involved omission and substitu-

tion of certain questions to make the questionnaire relevant to the Bhutanese context. The original questionnaire had been developed in a high-income country with advanced medical technology, much of which is not available in low-income countries. Questions on some of these advanced technologies were omitted (*eg*, automated disinfection systems), or substituted with those being used in the country (*eg*, chemotherapy gloves substituted with plain gloves). In addition, questions on laboratory, dental, and cleaning chemicals were adapted from OccIDEAS to make the questionnaire more comprehensive in assessing chemicals that HCWs use in Bhutan. The experts agreed that the modified questionnaire was comprehensible, comprehensive, and relevant to the Bhutanese context.

The reliability of the questionnaire was assessed by test-retest analyses. There was a high degree of agreement on the questions asking about the main tasks carried out. The only exception was the question asking about whether they worked in surgery, which demonstrated fair agreement. This could be because the question was not well understood as stated by one of the participants in the feed-back, who found this question confusing. It is important that words used in the questionnaire are clear and unambiguous for optimum comprehension and accurate interpretation.<sup>21</sup> Therefore, this question was re-worded as “do you work in the operation theatre?” in the final questionnaire to make it clearer. Since the majority of participants reported cleaning the workplace as one of their main tasks, the reliability of the additional questions on cleaning was also assessed. These questions on the use of various chemicals and control measures also demonstrated very strong agreement.

The information gathered from the questionnaires at the two time periods was sufficiently consistent to result in excel-

lent agreement in exposure assessment. Detailed self-reported occupational exposure information gathered from questionnaires has previously been shown to have a high degree of sensitivity<sup>22</sup> and reliability<sup>23</sup>. Using a list of specific agents to prompt recall, asking about agents that can be easily identified, and using familiar terminology (*eg*, using trade names instead of generic names), is known to improve accuracy of exposure assessment when using questionnaires.<sup>22</sup>

The main difficulties reported in using the questionnaire in this study were the length of the questionnaire and the tediousness in looking for the next questions after the skip questions. This is to be expected because the original questionnaire was designed for use as a Web-based survey, where the questions after the skip questions would be presented automatically, and the main questions would help screen the subsequent questions, thus, making the survey shorter. However, as indicated by both the study participants and the expert panel, the hard-copy version was the preferred mode of questionnaire administration in Bhutan. Both on-line and traditional paper-based surveys have been shown to be comparable in terms of reliability and validity,<sup>24,25</sup> and the selection of the most appropriate method depends on factors such as study aims, budget, and geographic area of the research.<sup>26</sup> The preference of the hard-copy version by participants in this study could be because the Web-based version requires an internet connection, access to which might be problematic in a low-income country like Bhutan due to the high costs and poor quality of internet connectivity.<sup>27</sup> So measures to improve the appearance of the questionnaire such as making the skip questions and page numbers more visible by presenting these in colored bold fonts, could assist in improving the usability of the hard-copy questionnaire.<sup>21,28</sup>

Cross-cultural adaptations of questionnaires usually involve translation, review by an expert committee, and pre-testing.<sup>29</sup> There are multiple ethnic groups (three main groups, many tribal groups) in Bhutan, each with their own language and, since English is used as the medium of instruction in all schools and institutions in Bhutan and therefore widely used,<sup>19</sup> administering the questionnaire in English was deemed appropriate, with a provision for the questionnaire to be administered as an interview in the local language when necessary (*eg*, for HCWs with little English proficiency such as cleaners, ambulance drivers). Although the questionnaire was not translated, almost all participants reported no difficulties in understanding the questionnaire endorsing the adequacy of presenting the questionnaire in English to Bhutanese HCWs.

The major limitations of this study were the use of a convenience sample and the small sample size. Although a sample size of 30 is adequate to achieve a power of 80% in detecting a problem with a 5% prevalence,<sup>30</sup> the results of this study, though encouraging, should be interpreted with caution due to non-random selection of the participants. In addition, despite attempts to recruit participants having a range of job titles, the majority were nurses and there was no representation of some job titles such as pharmacists. Furthermore, having the questionnaire only in English requires presenting the questionnaire as an interview in the local language by experienced interviewers to those workers with limited English proficiency, which could affect study resources such as time and costs.

The process of questionnaire adaptation and testing used in this study could assist in developing questionnaires for other LMICs. This process could be useful for countries with similar health care systems and medical technology.

This is one of the few studies testing a questionnaire to examine occupational exposures to chemical hazards in LMICs. The overall findings from this study suggested that the modified questionnaire had good validity and reliability to measure workplace exposures to hazardous chemicals among HCWs in Bhutan. Administering the questionnaire in English, with a provision for interpretation when required, was suitable for Bhutanese HCWs, and translation of the questionnaire was not imperative. The hard-copy version was the preferred mode of questionnaire administration.

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