Mechanical and Physical Risk Prevention

Studies and Research Projects

REPORT **R-803**

Worker Evaluation of Manual Dexterity, Tactile Sensitivity and Comfort When Wearing Needlestick-Resistant Gloves

Exploratory Study

Chantal Gauvin
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irsst

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PEER REVIEW

In compliance with IRSST policy, the research results published in this document have been peer-reviewed.

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ABSTRACT

Police officers, correctional service officers, garbage collectors and municipal gardeners are very concerned about the risks of injuries from hypodermic needles, which could expose them to potentially contaminated blood and the risk of contracting blood-borne infections such as human immunodeficiency virus and hepatitis B and C. Workers in these occupations therefore need to wear gloves that are not only needlestick resistant, but also provide adequate manual dexterity and tactile sensitivity. As there are relatively few models of needlestick-resistant gloves on the market, the choice is very limited. The purpose of this study was to conduct an exploratory evaluation of manual dexterity, tactile sensitivity and comfort when needlestick-resistant gloves are worn on the job.

Different glove models were tested by three groups of workers: police officers, garbage collectors and gardeners. Volunteers from each group performed typical work tasks and then filled in a perception questionnaire to give their opinions of the gloves in terms of dexterity, tactile sensitivity and comfort. Six police officers (three for pistol shooting and three for defence/restraint and control) tested five models of glove, two garbage collectors tested four models and two gardeners tested three models. The gloves tested were made by HexArmor (which uses SuperFabric®) and Warwick Mills (which uses TurtleSkin®). The scope of the study was relatively limited, as only a small number of subjects were involved.

None of the gloves tested by police officers was deemed satisfactory for pistol shooting, which demands fine dexterity and good tactile sensitivity for the delicate handling required. Model WM 006 was rated highest, however. For defence and for restraint and control techniques, models HX 9005 and WM 006 were judged to have the best potential, with the other models proving too slippery for handling the various types of police equipment. The garbage collectors deemed model HX 9005 to provide the best manual dexterity and the best tactile sensitivity. The gardeners rated models HX 9005 and HX 4042 the highest, but they aren’t waterproof, which is essential for gardening.

Generally speaking, the most flexible models—HX 9005 (only one layer of SuperFabric® in the palm) and WM 006—offer the greatest dexterity and tactile sensitivity and are the most comfortable, but they are less resistant to hypodermic needlesticks. With most of the gloves tested, folds tended to form in the palm when wearers closed their hands, causing skin irritation and discomfort and making it harder to perform manual tasks. In addition, the glove stitching proved to be quite uncomfortable and reduced tactile sensitivity.

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1. INTRODUCTION

1.1 Occupational Health and Safety Issue

The risk of accidental needlestick by contaminated medical needles is associated with the risk of contracting blood-borne infections, such as the human immunodeficiency virus (HIV) and the hepatitis B (HBV) and C (HCV) viruses. This risk is widely recognized in the medical community [1-4]. While health care workers are the group most directly concerned, other occupational groups are also exposed to the risk of needlestick with potentially contaminated needles or syringes, especially police officers, correctional service officers and maintenance workers [3,4].

The risks of occupational exposure to infectious diseases and of transmission of an infectious agent depend on a number of factors [2,5,6]:

- Type of virus
- Type of exposure (percutaneous or transcutaneous; mucocutaneous; nonintact skin)
- Prevalence of infectious diseases in people thought to be source of exposure (called source persons or source individuals)
- Quantity of virus found in blood of source individual at time of exposure
- Quantity of blood involved in exposure
- Frequency of exposure
- Viability of virus outside of the body (e.g., on a contaminated needle or other sharp object)
- Time between when needle or sharp is used and when injury occurs
- Injured individual's immune system
- Availability and use of postexposure prophylaxis

Exposure to HIV, HBV or HCV is considered significant when the blood (or other bodily fluid capable of transmitting the virus) of the potential source comes into contact either with subcutaneous tissue (percutaneous exposure through a needlestick or cut, for instance), mucous membranes (mucocutaneous exposure through the eyes, nose or mouth) or with nonintact skin (chapped or cracked skin, scrape, etc.) of the exposed individual [6]. The risk of being infected as a result of percutaneous occupational exposure is estimated to be between 6% and 30% for HBV, around 1.8% for HCV and 0.3% for HIV [2].

In the United States, from 1998 to 2000, the annual frequency of occupational exposure (all types combined) to infectious diseases in terms of number of exposures per 1,000 workers in full-time equivalents has been estimated to be 15.3 for nurses, 13.9 for laboratory technicians, 3.3 for police officers, detectives and public service workers, and 0.3 for janitors and maintenance workers [3]. When these groups of workers are exposed as a result of needlestick, it usually occurs with hollow cylindrical (hypodermic) needles. The risk of infectious transmission is higher with hypodermics because the quantity of blood inoculated in an injury is close to twice that inoculated with suture needles [7]. A report published in 2001 as part of the Canadian

HIV/AIDS strategy states that the documented or probable cases of occupational transmission of HIV reported in Canada (1 documented case + 2 probable cases), the United States (56 documented + 138 probable) and Europe (35 documented + 68 probable) were almost exclusively among health care workers and lab technicians [6].

Most of the scientific studies conducted among **police** or in a **correctional setting** show that the risk of occupational exposure for police officers and correctional service officers is significant. While the exposure frequency is thought to be relatively low, the seroprevalence of blood-borne infections in people who are arrested or incarcerated is high.

Among **police officers**, the annual frequency of exposure has been estimated to be 68 per 10,000 officers in Amsterdam [8], 39 per 10,000 in New York City [9] and 25 per 10,000 in Denver [10]. In most of these studies, the most frequent types of exposure are human bites and contact between the blood of the individual arrested and the injured skin of the arresting officer. Exposures as a result of needlesticks account for 9.5% to 12% of reported cases of exposure [8-10]. Though less common, needlesticks represent a higher risk of pathogen transmission than bites [11]. A survey of the San Diego Police Department found that close to 30% of respondents reported having suffered occupational needlestick injuries at least once, and a quarter of those officers more than once [12]. In another study, conducted in two U.S. cities [13], 0.9% of responding police officers reported occupational exposure through needlestick in the six months leading up to the survey. The higher needlestick incidence of the San Diego study can be explained by the fact that that survey was not limited to a specific length of time, but applied to all the years the respondents had served with the force (from 1 year to 16 or more years). This type of incident may be significantly underreported [4,10,12]. For example, only 39% of officers who suffered needlestick injuries had sought medical care at the time of the injury in the San Diego study [12], and only 43% in the Denver study [10].

Exposure frequency varies with an officer's duties and seniority. According to the results of the San Diego Police Department survey, needlesticks occurred chiefly on patrol (85% of respondents) and more specifically during searches (frisks following arrests, for 61% of respondents) [12]. This finding was confirmed by the study of the Denver Police Department, which estimated the frequency of annual exposure (by bite, needlestick or otherwise) to be 255 per 10,000 officers for those assigned to patrol and 389 per 10,000 for those assigned to urban crime [10]. The San Diego survey reported that 64% of respondents had sustained their first needlestick injury during their first five years on the job. The New York study suggested that occupational exposure is most frequent in the period from 4 to 10 years of service [9].

Among **correctional service officers**, occupational exposure to infectious diseases seems to be fairly comparable to that of police officers. A survey of U.S. public safety workers revealed that 6.6% of correctional service officers reported having been exposed to potentially HBV-contaminated blood in the six months leading up to the survey, compared with 7.4% of police officers [13]. While the rate of occupational exposure to HBV was slightly lower for correctional service officers than for police officers, exposure through needlesticks was higher in correctional services (2.4%) than among police (0.9%). In addition to needlesticks, the other types of exposure documented among correctional service officers were cuts by contaminated objects (2.0%) and human bites (3.2%). In Australia, one survey indicated that 66% of correctional service respondents had found syringes or needles in the course of their work, and that 7% of

respondents had suffered needlestick injuries [14]. Most of the needlesticks occurred when people, cells or other places were being searched. Among health care workers in a prison setting, exposure to HIV, HBV and HCV has been estimated to be 32 per 100 workers per year [15].

The infectious disease seroprevalence of **people at the source of the occupational exposure** of police officers and correctional service officers is substantially higher than in the general population [8,16]. For instance, over 60% of the men arrested on the Island of Manhattan by New York City police officers were injection drug users [9]. The seroprevalence of such drug users is high: it is estimated to be between 3% and 33% for HIV, between 30% and 80% for HBV and between 60% and 93% for HCV [12,16-19]. However, even though police officers reported having been exposed to the blood of HBV-, HCV- or HIV-positive individuals, no seroconversions were seen [8,10]. The prevalence of these infectious diseases among police officers and correctional service officers seems to be comparable to that in the general U.S. population, and is associated primarily with risk factors unrelated to work [8,13,19].

While the risk of occupational exposure of **garbage collectors** and maintenance workers is recognized, chiefly because of the inappropriate disposal of needles in garbage cans [3,20], relatively few studies have been done on this topic. The number of needles found in trash by New York City garbage collectors fluctuated between 1997 and 2002, ranging from 100 to 238 needles seen and from 11 to 33 needlestick injuries per year [20]. In Montreal, an analysis of the files of a postexposure prophylaxis referral centre revealed that 76% of cases of percutaneous exposure (primarily by needlesticks) were occupational, with 5.9% of cases associated with housekeeping and 1.5% with garbage collection [21]. In Washington state, 10% of garbage collectors who responded to a survey reported having sustained a needlestick injury in 1988 [22]. In Mexico City, one study indicated that 96% of 69 garbage collectors surveyed had seen needles or syringes in the trash (55% had seen needles at least five times in the week before the survey) and that most of the needles had been seen in trash in residential areas [23]. Of these garbage collectors, 34% had experienced one to five needlestick injuries.

The occupational exposure of **gardeners** has not been documented in the scientific literature, as far as we know. However, it is common knowledge that needles are sometimes found in public places, especially parks. The gardeners who maintain these parks could be at risk of needlestick injury. In Sydney, Australia, 120 cases of patients presenting to a hospital emergency ward with needlestick injuries were reported. Of these cases, 36% were occupational in origin, including over a third associated with maintenance of toilets, beaches and parks, and the needles found in gardens or parks caused 7.5% of the injuries [24]. According to a U.K. study, 6% of the accidental needlestick injuries in the community occurred in a park [25]. Another study, on accidental needlestick injuries in children, revealed that 30% of the syringes involved had been found in parks [26].

For the present study, a request was submitted to the IRSST by correctional services, municipal police officers and public works through the APSSAP[1] and the APSAM,[2] asking for assistance in identifying gloves that would protect workers' hands against cuts and needlesticks while still affording them as much dexterity, tactile sensitivity and comfort as possible. These occupational groups are very concerned about the risks of needlestick injury from potentially contaminated needles. The request indicated that correctional service officers sometimes find used syringes when they search inmates' personal effects. Municipal police officers report that they also face this problem during police operations, altercations or when searching individuals or vehicles. Garbage collectors say they often find used syringes when picking up trash or cleaning up sewers and parks. Gardeners also find dirty syringes when doing maintenance of public areas, especially when weeding flower beds and tidying up around shrubs. The request was initiated by a detention centre and the correctional service branch of Quebec's Ministère de la Sécurité publique on behalf of correctional service officers assigned to conduct searches. It was backed by municipalities and police organizations.

1.2 Background and State of the Art

When this project began, there was no standard test method for characterizing the needlestick resistance of gloves. To respond to the request to identify needlestick-resistant gloves, the IRSST teamed up with the École de technologie supérieure (ÉTS) to conduct a research project in cooperation with the joint sector-based associations and employer and union representatives from the occupational groups concerned [27]. As part of the project, a test method was developed to characterize the hypodermic needlestick resistance of protective gloves. The method consists in measuring the force required to puncture a sample of the protective material with a needle travelling at constant speed perpendicular to the sample. This work led to the development of a standard test method [28] that was approved in 2010 by ASTM International[3] Committee F23 on personal protective clothing and equipment. Needlestick resistance measurements for 58 glove models available on the market revealed that four types of glove provide the best protection [27]: (1) gloves having one or more layers of SuperFabric® (material developed and made by HDM Inc., Oakdale, MN [29]), which consists of tiny hard dots adhering to a fabric backing; (2) gloves that use TurtleSkin® technology (Warwick Mills Inc., New Ipswich, NH [30]), which consists of tightly woven aramid fibres; (3) gloves consisting of several superimposed layers of nylon; and (4) gloves containing a fine metal mesh.

Generally speaking, protective gloves adapted to a specific type of risk do help protect the hands. Wearing them can help prevent slight to moderate injuries [31,32,33]. Studies have shown that latex or nitrile gloves reduce the risk of infection transmission in the event of accidental needlestick [34,35]. While surgical gloves do not prevent needlestick penetration of the skin, they reduce by 52% the volume of blood transmitted by a hollow needle when compared with wearing no gloves [35]. However, at the same time, protective gloves can significantly reduce

[1] Association sectorielle paritaire pour la santé et la sécurité du travail – secteur administration provinciale [joint sector-based occupational health and safety association – provincial administration sector].

[2] Association sectorielle paritaire pour la santé et la sécurité du travail – secteur affaires municipales [joint sector-based occupational health and safety association – municipal affairs sector].

[3] Formerly known as the American Society for Testing and Materials.

work performance by affecting dexterity [36-38], tactile sensitivity [39-42], grasp force [43-45] and hand movement [46], especially when the glove material is thick. These are the main reasons workers give for not wearing gloves [33,47-49]. Among workers who do wear gloves, some have a habit of altering their gloves, by cutting off the finger tips, for instance, to increase their dexterity [50]. The feeling that gloves interfere with work is a major factor in a worker's decision about whether to wear them or not [47]. Dexterity and comfort are therefore just as important for worker safety as actual protective properties, because they have a significant bearing on a worker's willingness to wear gloves [51].

In this study, dexterity is determined by the degree to which glove wearers can move their arms, hands and fingers precisely, quickly and with good coordination when performing manual tasks, such as handling objects [52]. Tactile sensitivity is the capacity to feel textures, shapes, sizes and other attributes by touch, and to detect any changes in these attributes [52]. Tactile sensitivity can refer to static touch (i.e., no movement between object and hand) or dynamic touch (i.e., relative movement between object and hand). Dynamic touch can be passive (i.e., hand stays still while object moves) or active (i.e., hand moves). In this study, tactile sensitivity was determined by active dynamic touch, i.e., the hand manipulates objects freely.

A number of studies have compared the dexterity, tactile sensitivity or comfort offered by different models of chemical-resistant [38,39,43,53-57] or surgical gloves [40-42,58,59]. All these gloves are made of polymer materials without a support or with a (coated) textile support. None of the studies concerned needlestick-resistant gloves or gloves made of multiple layers of a textile material. The National Institute of Justice (NIJ) in the United States has taken an interest in protective gloves for police and correctional service officers exposed to needlestick hazards. It has established test protocol 99-114 [60] based on standard test methods for evaluating the performance of protective gloves according to different criteria, i.e., pathogen resistance, cut resistance, puncture resistance (puncture by round-tip conical probe), tear resistance and ability to provide wearers with adequate dexterity. This protocol did not include testing with hypodermic needles, as at the time it was drawn up, there was no standard test method for characterizing the needlestick resistance of gloves. The NIJ has evaluated and compared a large number of protective gloves using the protocol [61].

In protocol 99-114 [60], the method used to measure dexterity is that found in British European Standard BS EN 420:1994 [62], whereby a subject wearing gloves must pick up five metal pins of increasingly smaller diameters: 11.0, 9.5, 8.0, 6.5 and 5.0 mm. The dexterity offered by the test glove is rated according to the smallest-diameter pin that the subject can pick up three times consecutively within 30 seconds, without undue fumbling. The finer the pin that can be picked up, the better the dexterity provided by the glove. However, a 2007 comparative study found that this method does not always provide an accurate assessment of the dexterity that gloves offer [63]. The study noted, for instance, that it is very easy to pick up the smallest diameter pin if the gloves are sticky, regardless of the actual dexterity they allow.

There are also other tests for laboratory measurement of manual dexterity [52,63]. They involve asking participants to perform specific tasks (e.g., place pins in holes, or put nuts and bolts together) as quickly as possible. A number of these tests have been used to evaluate the dexterity provided by chemical- and heat-resistant protective gloves [38,54-59,64,65], including the Minnesota Rate of Manipulation Test [66], the O'Connor Finger Dexterity Test [67], the Bennett

Hand-Tool Dexterity Test [68] and the Purdue Pegboard Test [69]. A few studies have also assessed the dexterity and tactile sensitivity of workers wearing gloves by having them perform work-specific handling tasks or having them wear gloves over the course of a regular shift [50,57,70]. This type of test also generally involves filling in a perception questionnaire. The questionnaires are developed to reflect given work situations and therefore differ from one position to the next and one study to the next. Being specific to the work environment, this method has the advantage of being an effective way to identify the gloves best suited to a worker's manual tasks.

To meet the dexterity, tactile sensitivity and comfort requirements stipulated in the request submitted to the IRSST by police and correctional service officers and public works employees, an exploratory study was undertaken to have the workers in question evaluate those aspects of protective gloves. The exploratory study is the subject of this report. As far as we know, no study regarding worker evaluation of the functional properties of needlestick-resistant gloves has so far been reported in the literature.

1.3 Goal of Study

The goal of the study was to conduct an **exploratory** evaluation of the performance of needlestick-resistant gloves in terms of the dexterity, tactile sensitivity and comfort required for workplace use. To this end, the following specific objectives were defined:

- Select commercially available gloves that meet the criteria for protection against needlesticks, cuts and punctures (round-tip probe). Choose from among models of glove for which the needlestick resistance had already been characterized in an earlier research project [27].
- Develop an experimental protocol based on typical work-specific tasks, as well as perception questionnaires for the different occupational groups.
- Have a restricted number of workers wearing fairly needlestick-resistant gloves evaluate them for dexterity, tactile sensitivity and comfort.

Police officers, garbage collectors and gardeners took part in the study.

2. METHOD

2.1 Subjects

A small number of volunteers were recruited for this exploratory study. No restrictions were set with respect to sex, age or hand size. The only requirement was to be an adult worker. Table 1 gives the positions and age ranges of the participants.

Table 1 Subjects: position, number of women (W)/men (M) and age

Occupa-tional group	Position	Number of subjects	Age (years)
Police officers	Instructors and monitors, shooting module, police department	2W, 1M	37 ± 4
	Instructors and monitors, defence and tactical module, police department	1W, 2M	36 ± 4
Garbage collectors	Municipal household garbage collectors	2W, 5M	28 ± 7
Gardeners	Municipal gardeners	1W, 2M	43 ± 7

Subjects were chosen by their departments, in cooperation with members of the research project follow-up committee and resource people in each workplace. They were free to agree or to decline to take part, as well as to drop out of the study at any time. They signed a consent form before the testing began.

2.2 Gloves

Glove models were selected on the basis of the results of a study conducted jointly by the ÉTS and the IRSST, in cooperation with joint sector-based associations and employer and labour union representatives of the occupational groups concerned [27]. For that study, the needlestick resistance of 58 models of gloves (acquired in 2007) was measured experimentally with 25-gauge (25G, or 0.5 mm diameter) needles travelling at a speed of 500 mm/min [27], following a method equivalent to new standard ASTM F2878-10 [28]. The puncture resistance of the 58 models was also measured, following standard ASTM F1342-05 [71], using a 2 mm diameter conical probe with a 0.25 mm radius rounded tip (standard probe A). Of the 58 glove models, 12 showed greater needlestick resistance than the others. For those 12 models, cut resistance was also measured, following standard ASTM F1790-05 [72]. Table 2 gives the protective properties and chief characteristics of the 12 models, taken from [27].

Table 2 Most needlestick-resistant gloves, according to [27]

ID code	Manufacturer/ Name/Model	R_{Needle} [N] (CV)	R_{Punc} [N] (CV)	R_{Cut} [gf] (R^2)	Picture (from manufacturer's website)	Materials (palm of glove)	Size
WM 003	Warwick Mills TurtleSkin Special Ops TWCS-003	9.7 (24%)	52.9 (7%)	1,908 (0.6)		TurtleSkin	XS to XXL
HX 7080	HexArmor SharpsMaster™ 7080	9.5 (24%)	71.2 (8%)	8,073 (0.5)		SuperFabric (3 layers) + nitrile coating	S to XXL
HX 9014	HexArmor SharpsMaster II™ 9014 (replaces HX 7080)	11.0 (21%)	107.1 (16%)	8,260 (0.9)		SuperFabric (3 layers) + rubber coating	S to XL
HX 4041	HexArmor HiDex NSR 4041	9.0 (26%)	45.3 (11%)	4,942 (0.8)		SuperFabric (3 layers) + polyester lining + silicon dot coating	XS to XXL
WM 002	Warwick Mills TurtleSkin Search TWCS-002	8.4 (27%)	54.7 (9%)	2,717 (0.6)		TurtleSkin + nylon lining	XS to XXL
HX 6044	HexArmor PointGuard X 6044 Note: Liner only, requires glove on top	8.4 (27%)	50.1 (8%)	6,162 (0.5)		SuperFabric (3 layers) + cotton	XXS to XXL
HX 4042	HexArmor HiDex NSR Leather 4042	6.9 (25%)	53.7 (7%)	3,852 (0.7)		SuperFabric (2 layers) + polyester lining + synthetic leather (suede finish)	XS to XXL
HX 8030	HexArmor 8030	6.3 (54%)	146.7 (17%)	5,025 (0.8)		Leather + SuperFabric* (1 layer) + aramid knit + cowhide	S to XXL
SUP SKLPSMT	Superior SKLPSMT	4.5 (14%)	22.7 (7%)	10,793 (0.5)		Leather + Kevlar + stainless steel mesh (1 layer)	S to XXL

ID code	Manufacturer/ Name/Model	R_{Needle} [N] (CV)	R_{Punc} [N] (CV)	R_{Cut} [gf] (R^2)	Picture (from manufacturer's website)	Materials (palm of glove)	Size
WM 006	Warwick Mills TurtleSkin Duty TWCS-006	4.2 (15%)	70.8 (44%)	800 (0.5)		TurtleSkin + genuine leather	S to XXL
HX 9005	HexArmor 9005	4.0 (46%)	37.7 (10%)	2,066 (0.5)		SuperFabric (1 layer) + knit + polyurethane coating	S to XXL
SUP 66BRPU 12N	Superior Glove 66 BRPU12N	3.4 (11%)	212.2 (4%)	1,122 (0.9)		Leather + 12 layers of nylon	one size

ID code: Glove model number

R_{Needle}: Needlestick resistance (tests conducted with 25G needle, following method equivalent to standard ASTM F2878-10), in newtons [N]

R_{Punc}: Puncture resistance according to standard ASTM F1342-05 with conical probe A (2 mm diameter; round tip with 0.25 mm radius), in newtons [N]

R_{Cut}: Cut resistance according to standard ASTM F1790-05, in grams-force [gf]: 1 gf = 0.0098065 N

CV: Coefficient of variation

R^2: Coefficient of determination

Size: XXS = extra-extra-small, XS = extra-small, S = small, XL = extra-large, XXL = extra-extra-large

*The SuperFabric used in HexArmor 8030 is different from that used in all other HexArmor models.

All the gloves listed in Table 2 were presented to the members of the study follow-up committee and the resource people from each occupational group. After trying the gloves on and discussing them, the representatives selected the models they thought would best suit their workers. The following models were selected:

- Police 5 models: WM 003, WM 006, HX 4041, HX 4042, HX 9005
- Garbage collectors 4 models: HX 4041, HX 8030, HX 9005, HX 9014
- Gardeners 3 models: HX 4041, HX 4042, HX 9005

Some of the chosen models are made by HexArmor (Grand Rapids, MI), which uses the protective material SuperFabric® developed by HDM Inc., while the others are made by Warwick Mills (New Ipswich, NH), which uses TurtleSkin®, a material it developed itself.

Superior Glove model SKLPSMT was not available at the time the gloves were chosen. Also, the garbage collectors group selected model HX 7080, but when it came time to order the gloves for

the study, the manufacturer, HexArmor, had discontinued it and replaced it with model 9014, which it said was equivalent but offered greater dexterity.

For the testing, the subjects tried on all the sizes available for each model and chose the one they found the most comfortable. Each subject had his or her own pairs of gloves for the tests.

2.3 Experimental Procedure

Workplaces were visited to find out more about the various manual tasks requiring protective gloves that workers had to do. The visits also provided an opportunity to talk to workers about the tasks, observe how gloves were used, what equipment or objects were involved and how workers handled the equipment or objects. Following the visits, an experimental procedure and a perception questionnaire specific to each occupational group were developed, in cooperation with the members of the study follow-up committee and the project resource people. In broad terms, the experimental procedure involved having the subjects perform typical workplace tasks, under conditions that minimized risks, and fill in a perception questionnaire to give their opinions on the dexterity, tactile sensitivity and comfort provided by each pair of gloves when they were performing the tasks. The perception questionnaires can be found in appendixes A to D of this report. The questions focused mainly on the following four topics:

1) Evaluation of dexterity and tactile sensitivity: The subjects were asked to perform typical workplace tasks, and the precise manipulations associated with them, wearing each pair of gloves, and to rate their dexterity and tactile sensitivity for different job-specific competencies, on a four-point scale (1 Very easy or fairly easy; 2 Reasonably doable, but requiring some effort; 3 Rather hard; 4 Very hard). As a benchmark, the subjects were asked to rate each glove in comparison with the model they usually wore at work. A competency generally corresponded to a task that required the worker to have a specific manual skill to perform the job satisfactorily. The competencies included using handcuffs or drawing a pistol, for police officers, and weeding, for gardeners. Each competency was broken down into various specific movements. For example, the specific movements involved in using handcuffs range from opening up the handcuff case to locking the cuffs around a person's wrists, and include applying a thumb lock to the person and using the key. Competencies and the specific movements they involved were identified through workplace visits. The relevance and appropriateness of the perception questions were validated by the resource people for the different occupational groups.
2) Evaluation of glove characteristics: Subjects were asked to rate the comfort, flexibility and grip of the gloves under dry and wet conditions. There was a four-point scale for comfort (1 Very comfortable to 4 Very uncomfortable); a two-point scale for flexibility (1 Flexible or 2 Stiff); and a two-point scale for grip (1 Satisfactory or 2 Unsatisfactory, i.e., too slippery).
3) Overall assessment of gloves: Subjects were asked to assign an overall rating to the gloves, based on their suitability for performing the different handling tasks, on a scale of 1 to 10 (where 1 is Poor and 10 is Excellent). They were instructed to base their assessment on the benchmark case of the glove model they usually wore at work.
4) Ranking: Subjects were asked to rank the models in order of preference—with respect to their ability to perform the work when wearing them—from best model (ranked first) to

worst (ranked last). They were also asked to comment on the gloves and/or offer suggestions for improving them.

All the questions on the questionnaire were approved by the resource people from the different occupational groups. Before the testing began, meetings were held with the participants to make sure they fully understood the testing procedure and the questions.

2.3.1 Police Officers

Police testing of the dexterity and tactile sensitivity provided by protective gloves was done through the training section of a police department. The following two tests were run:

1) Use of a pistol by three police instructors/monitors in the shooting module of the training section
2) Defence and restraint/control manoeuvres by three police instructors/monitors in the defence and tactical module of the training section

For each experiment, the subjects conducted the corresponding tests six times, in random order: with bare hands and wearing each of the five glove models selected for the study. They performed the tests first under dry conditions, with new, dry gloves; then, if the gloves were deemed suitable for the work, they did the same tests under wet conditions. In that case, the gloves were sprayed copiously with water before the tests were done.

Before the testing, the subjects were given time to familiarize themselves with the different gloves and to try out the various handling tasks while wearing them. The tests were spread out over several, not necessarily consecutive, days so as not to disrupt the instructors/monitors' regular work.

2.3.1.1 Pistol Shooting

The pistol handling tests consisted in going through a course of fire designed for police training and performing the two techniques for clearing a jammed weapon. A police officer's firearm equipment consists of a Walther P99 pistol, a holster and a carrier that can hold two magazines. The holster has a two-level retention system to prevent someone from grabbing the pistol during an altercation. The main parts of the Walther P99 pistol are identified in Figure 1. The course of fire involved shooting a maximum of 30 rounds at a cardboard target from different shooting positions (face on, sideways, etc.) at different distances from the target (from 2 to 20 m), within a specific time frame (from 2 to 15 seconds per shot). An 8½" x 11" sheet of paper was glued to the cardboard target, as shown in Figure 2. The purpose of the sheet of paper was to make the shooting more difficult by reducing the target size, as all the subjects were firearms instructors and therefore had no trouble hitting the cardboard carton with all their rounds.

Figure 1 Parts of Walther P99 pistol

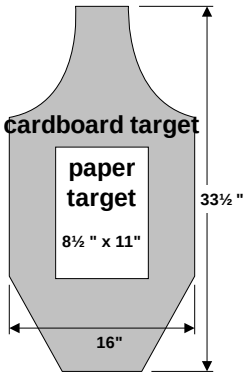

Figure 2 Target

For each subject, glove performance was evaluated on the basis of (1) the number of shots that hit the smaller paper target and the larger cardboard target during the course of fire (N.B., a police officer must hit the cardboard target with at least 24 shots out of 30 in order to qualify each year); and (2) the feedback provided on the perception questionnaire (Appendix A). The experimental procedure provided an opportunity to test the glove models with respect to the following competencies, each of which consists of six to eight tasks:

Drawing, reholstering (i.e., removing pistol from holster and replacing it). Go through two retention levels to remove pistol from holster (level 1: swivel semirigid strap forward, and level 2: unholster weapon); reholster weapon, with and without looking; do quick draw.

Loading and unloading magazine (i.e., ejecting almost empty magazine and replacing it with fresh one). Press magazine release catch to eject empty magazine; open magazine holder and take out new, full magazine; with index finger, feel first round in magazine; insert magazine into pistol without looking and tap bottom of magazine to make sure it is seated properly; pull slide back sharply; do fast reload.

Shooting (i.e., holding and firing pistol). Hold pistol firmly, as usual; insert finger in trigger guard; pull trigger in one smooth, continuous motion; feel trigger as pistol fires; shoot accurately; shoot quickly.

Clearing a jam – Level 1 (Tap-Rack-Ready) **and level 2** (Lock-Rip-Cycle-Tap-Rack-Ready) **methods** (i.e., clear stoppage in pistol's cycle of operation so you are ready to fire again). Strike bottom of magazine to make sure it is seated properly (tap); pull slide back sharply to chamber cartridge (rack); press slide catch lever to lock slide back (lock); eject magazine (rip); pull slide back sharply twice to eject round from chamber (cycle); take up ready-to-fire position again (ready).

All the testing was conducted at the police department's firing range. The tests for each glove model lasted from 20 to 60 minutes.

2.3.1.2 Defence/Restraint and Control

The defence and individual restraint and control tests consisted in performing various police training procedures and exercises for restraining people. Each subject evaluated glove performance by giving feedback on the perception questionnaire (Appendix B). The testing provided an opportunity to assess the gloves' suitability for the competencies described below, which each involve from 4 to 11 tasks:

Pepper spray. Open holder and take out spray can; handle can, hold correctly and feel it in hand without looking; spray using index finger; spray using thumb; replace can in holder.

Expandable baton. Remove baton from holder; deploy baton in collapsed or expanded configuration; use different warding-off, blocking and retention techniques; press button to collapse baton; replace baton in holder.

Flashlight. Remove flashlight from holder; press button to turn on; handle flashlight; replace flashlight in holder.

Handcuffs. Open handcuff case; take handcuffs out and position them without looking; grasp subject's thumb without it slipping; be able to feel joint lock applied properly; put on first cuff and close it; do same with second cuff; take out key and lock cuffs; remove cuffs safely.

Search cooperative subject while standing. Make non-violent contact with individual by grasping elbow; frisk subject for knife, syringe or handcuff key; search individual while maintaining firm grip on clothes (shirt collar).

Restraint techniques. Use joint lock techniques; when working in team, put restraining belt on individual lying in prone position; use pressure points (mandibular angle, hypoglossal) to control sitting individual.

Use emergency button on two-way radio. Press emergency button on two-way radio.

All the testing was conducted at the police department's training centre. The tests for each glove model took from 20 to 60 minutes.

2.3.2 Garbage Collectors

The dexterity and tactile sensitivity offered to garbage collectors by various models of protective gloves were evaluated in the course of their regular work and under conditions that minimized their risks. The subjects each wore the four glove models selected for the study while collecting household trash by hand. The collectors worked their usual route, holding onto the grab bars while standing on the running boards at the rear of the truck. They collected trash from the curbside, throwing or dropping it into the truck hopper, or emptied garbage cans into the hopper and set them back down on the curb.

The subjects tested each model of glove twice, on two different days, in the summertime, so as to expose them to a variety of weather conditions (sunshine, rain, humidity, heat), for around one hour per model each time. They tested two glove models per day.

At the end of the route, but before the end of their shift, the subjects filled in the perception questionnaire (Appendix C) to give their feedback on the gloves they had tested. They were allowed to change or further complete an already-filled-in questionnaire for a glove model after testing it for the second time. The questionnaire covered the following competencies, with each competency including from three to seven tasks:

Use "ring" hold to pick up garbage bags. Grab bags in "ring" hold without hands getting tired; same under cold or wet conditions; be able to feel bunching of bags in hand when grabbing in "ring" hold (without needing to look); get good grip, without irritating folds in glove material.

General collection of household garbage. In dry weather, pick up bags without having them slip out of hands; same in wet weather (bags wet from rain); be able to feel shape of objects to be handled, without having too much difficulty bending fingers; make fine movements to grasp small items, pick up several small bags at once, operate hopper levers, etc.; throw bags into hopper without gloves slipping off hands and being pulled along with bags; pick up, pull or push heavy objects; feel weight of objects through gloves.

Safety issues. Hold onto truck's grab bar without slipping; hold onto grab bar without hands getting tired; don't get stuck to an object, garbage or truck; don't run risk of being pulled into compactor.

2.3.3 Gardeners

The dexterity and tactile sensitivity offered to gardeners by various models of protective gloves were evaluated in the course of their regular work and under conditions that minimized their risks (notably in places where the risks of coming across needles were low).

The experimental procedure consisted in having each subject wear each of the three selected models of glove for at least one hour while weeding flower beds and around shrubs and pruning rosebushes, which were the test activities for thorn-resistant gloves. The questionnaire (Appendix D) provided an opportunity for the gardeners to give their feedback on the gloves with respect to the following competencies, which involved from two to seven tasks each:

Weeding. Be able to feel plants with fingers; distinguish different parts of plants (branches, stems, leaves, flowers, etc.) by feel; remove weeds by hand; grasp plants to pull them out; use hand tools (rake, weeding tools) without losing grip, and same when gloves are wet; hold hand tools without hands getting tired (gloves flexible enough? gloves provide good enough grip?).

Rosebush pruning. Be able to feel different parts of rosebush well enough to distinguish stems, leaves, flowers, etc., by touch; pinch stems; use hand secateurs/shears without losing grip, and same when gloves are wet; grasp secateurs/shears without hands getting tired (gloves flexible enough? gloves provide good enough grip?).

Resistance to rosebush thorns. Be able to move branches without gloves getting caught on thorns, branches or leaves; be able to prune rosebushes without getting pricked by thorns.

Depending on what gardening tasks were scheduled, several models of glove could be tested on the same day, or a given model could be tested over several, not necessarily consecutive, days, so that testing could be done under different weather conditions. Following the tests, the subjects filled in a perception questionnaire to give their feedback on the models they had worn.

2.4 Data Analysis

The perception questionnaire results were compiled by occupational group. For the evaluation of the dexterity and tactile sensitivity provided by the gloves for specific handling (part 1), the ratings given (from 1 easy to 4 hard) for the different tasks were averaged by competency, for each subject (identified as S1, S2, S3) and each model of glove. Then, for each glove model, the average rating was calculated for all competencies and all subjects. The closer the average rating was to 1, the more the glove had the potential to provide satisfactory dexterity and tactile sensitivity for the workers in the group.

For the evaluation of glove comfort, flexibility and grip (part 2), the ratings (with 2-point or 4-point assessment scales) were averaged for all subjects for each model of glove. The closer the average rating was to 1, the more satisfactory the glove was deemed. The ratings were then averaged for all characteristics.

Lastly, the overall assessment ratings on a scale of 10 (part 3) and the ranking of the glove models by order of preference (part 4) were also averaged over all subjects for each model of glove.

The questionnaire results are presented in tables 4 to 7 in the next section. To make the results easier to read, the average ratings for each of the four parts of the questionnaire are presented in the shaded rows of the table.

3. RESULTS AND DISCUSSION

3.1 Police

3.1.1 Pistol Shooting

The gloves were evaluated for suitability for firearm use by three police instructors/monitors (two women and one man). The officers went through a course of fire and performed two techniques for clearing a jammed pistol, wearing five models of glove, in dry and wet conditions. The performance of the gloves was evaluated on the basis of the number of shots that hit the target during the course of fire and the feedback given in the perception questionnaires.

Table 3 shows the number of shots that hit the smaller paper target and the larger cardboard one (see Figure 2), out of a maximum of 30 rounds, for each subject (S1, S2 and S3) and for each model of glove, under dry conditions.

Table 3 Results of course of fire under dry conditions

Glove models	Number of hits in paper target // cardboard target		
	S1	***S2***	***S3***
Bare hands	30 // 0	30 // 0	28 // 2
WM 003	30 // 0		
HX 4041	27 // 3		
HX 4042	30 // 0		
WM 006	30 // 0	26 // 4	25 // 5
HX 9005	30 // 0		

For the course of fire, subject 1 hit the paper target with the maximum 30 shots while wearing all the gloves except model HX 4041. Despite this good performance, subject 1 felt that the gloves were generally not suitable for pistol shooting, as discussed below. Subjects 2 and 3 did the course of fire only barehanded and wearing glove model WM 006. The two subjects deemed that the other models were completely unsuitable for shooting and not safe enough for that use. Table 3 shows that subjects 2 and 3 hit the paper target fewer times while wearing model WM 006 than while barehanded, indicating that they found it harder with the gloves. None of the subjects did the course of fire under wet conditions because overall they deemed the gloves to be unsuitable for shooting, even under dry conditions.

All three subjects of the pistol-shooting police group filled in the perception questionnaire. Table 4 gives the results of the evaluation of dexterity and tactile sensitivity, under dry conditions, as perceived by the subjects when performing some 20 manipulations while wearing the gloves. The various manipulations were grouped under four competencies (part 1). The subjects noted more or less the same things during testing under wet conditions. Also presented in Table 4 are the ratings of glove comfort, flexibility, grip when dry and grip when wet (part 2), the overall assessment of the gloves (part 3) and the ranking of the gloves by order of preference based on their suitability for the manipulations (part 4).

Table 4 Evaluation of five models of glove by three subjects in police group – pistol shooting

Questionnaire sections Police – pistol shooting	**Glove models**														
	WM 003			**HX 4041**			**HX 4042**			**WM 006**			**HX 9005**		
1) Dexterity and tactile sensitivity for indicated competencies (1 Easy to 4 Hard)	**2.1**			**2.8**			**2.8**			**2.1**			**2.5**		
Subjects	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*
Draw, reholster	4.0	1.3	1.0	4.0	1.5	1.2	4.0	1.0	1.3	4.0	1.0	1.0	3.2	1.7	1.7
Load, unload	4.0	1.1	1.1	4.0	2.4	2.4	4.0	1.9	2.5	4.0	1.3	1.0	3.4	2.0	1.8
Shoot	4.0	1.4	1.0	4.0	2.4	2.4	4.0	3.6	4.0	4.0	1.0	1.0	3.7	3.4	4.0
Clear a jam	4.0	1.0	1.0	4.0	2.7	3.2	4.0	2.0	2.0	4.0	1.3	1.0	3.0	1.7	1.3
2) Glove characteristics (1 Satisfactory)	**1.8**			**2.0**			**2.0**			**1.3**			**2.0**		
Comfort (1 Satisfactory to 4 Unsatis.)	3.3			2.7			3.3			1.7			3.3		
Flexibility (1 Flexible, 2 Stiff)	1.3			1.5			1.3			1.0			2.0		
Grip when dry (1 Satisfactory, 2 Slippery)	1.0			1.7			2.0			1.3			1.3		
Grip when wet (1 Satisfactory, 2 Slippery)	1.5			2.0			1.5			1.3			1.7		
3) Overall assessment (10/10 Excellent)	**5/10**			**1/10**			**2.3/10**			**6/10**			**2/10**		
Subjects	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*
Overall assessment (/10)	1	7	8	1	1	1	1	3	3	1	8	9	3	2	1
4) Ranking (1 Best)	**2**			**5**			**3**			**1**			**4**		
Subjects	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*
Ranking	5	2	2	4	5	5	3	3	3	2	1	1	1	4	4

The evaluation results for the pistol-shooting police group were mixed. The perceptions of subjects 2 and 3 contrasted with those of subject 1 in several respects. Despite the differing opinions, the results clearly show that a number of tasks were fairly difficult to do while wearing gloves or, at best, were doable only with a certain amount of effort, as indicated in Table 4 by the evaluation of dexterity and tactile sensitivity, with average scores of over 2.0 (from 1 Easy to 4 Hard) for all the models. In particular, tasks requiring fine motor skills (such as pressing the magazine catch), most shooting-related tasks and quick handling (such as fast reload) were hard to perform with gloves. The subjects found it difficult to get their finger inside the trigger guard while wearing gloves HX 4042 and HX 9005. The gloves that, overall, seem to offer the best potential for pistol shooting are models WM 006 and WM 003, which were given the best evaluations for dexterity and tactile sensitivity (with average scores of 2.1/4).

Gloves WM 006 and WM 003 are also the models that subjects 2 and 3 preferred, as indicated by the average overall assessment scores given in Table 4, which are 6/10 and 5/10 respectively. The two models seem to provide fairly good grip, according to the subjects, with evaluations of 1 for glove WM 003 and 1.3 for glove WM 006. However, some of the subjects found model

WM 003 to be very slippery in wet conditions. In contrast, model WM 006 seemed to be significantly more comfortable and more flexible than model WM 003. Still, even though WM 003 is one of the two models rated highest by subjects 2 and 3, they and subject 1 indicated in their comments that it is nevertheless very uncomfortable to wear and can cause pain in the fingers when closing the hand because of the stiffness and folds in the material covering the palm.

The results for model HX 9005 were very mixed. While it was the top choice of subject 1, who nonetheless gave it a pretty low rating (3/10), the other two subjects ranked it fourth (with ratings of 2/10 and 1/10).

The subjects of the pistol-shooting police group had a number of comments about the gloves, but the remarks are of limited significance, as we were unable to validate them with a larger sample of subjects. The main comments, generally shared by all three subjects, are given below:

- For all the gloves, with the possible exception of model WM 006, the fabric of the palm does not fit tightly to the hand and tends to bunch into folds, not only making the gloves quite uncomfortable to wear, but also making it hard to handle a pistol (Figure 3).
- Most of the models, with the exception of WM 006, are so stiff that they cause pain in the joints, fingers and thumb when fingers are flexed (Figure 3).
- The fingertips of the HexArmor gloves (HX 4041, HX 4042 and HX 9005) are too thick and too stiff to allow satisfactory tactile sensitivity.
- On all the gloves, there is stitching right at the fingertips, which the subjects said considerably reduces dexterity, tactile sensitivity and comfort. One subject suggested it would be better if the stitching were on the top of the fingers (Figure 3).
- For one of the subjects, the lining of gloves HX 4041 and HX 4042 tore during the testing and came out of the glove (while staying stitched at the wrist), making it almost impossible to put the gloves back on again. Another subject noted that some of the tiny hard dots on the SuperFabric® (needlestick-resistant material) of model HX 4041 came off the backing when the pistol was handled.

Police officers usually have to be able to handle their firearms without looking at them. They have to be able to feel where their fingers are, without looking, and whether they have a firm grip on the pistol. A poor grip can result in inaccurate shooting, which can increase the risk to the life of the police officer and the lives of others. One of the subjects noted that with most of the gloves tested, it is hard to know whether your finger is touching the magazine catch or the trigger, as the two are located very close together on the Walther P99 (see Figure 1). The subject thought this represented a risk of firing the weapon accidentally. In addition, in the same subject's opinion, police officers who rarely have an occasion to use their firearms may not realize that their grip is defective, and could end up shooting inaccurately or missing the target completely. Those remarks were not confirmed by the other participants.

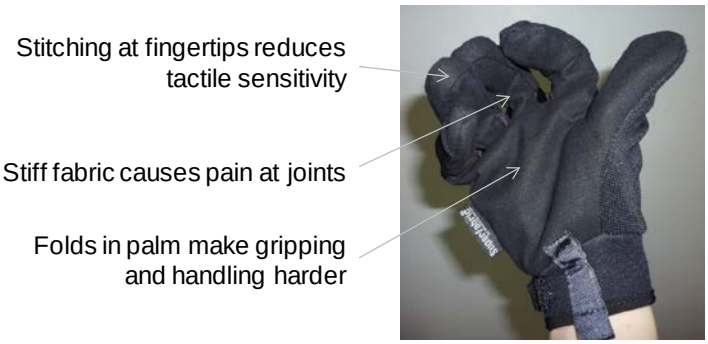

Figure 3 Attributes perceived as making glove uncomfortable

3.1.2 Defence/Restraint and Control

With respect to suitability for defence techniques and restraining and controlling individuals, the gloves were evaluated by three police instructors/monitors (one woman and two men). The three subjects performed the various manoeuvres while wearing five different models of glove, in dry and wet conditions, and gave their feedback by filling in the perception questionnaire.

The results for the defence/restraint-and-control police group are given in Table 5. Part 1 of the table presents the ratings for dexterity and tactile sensitivity with reference to some 40 manipulations performed with the selected gloves under dry conditions. The manipulations were grouped under seven competencies. Table 5 also gives the ratings for glove comfort, flexibility, grip in dry conditions and grip in wet conditions (part 2), the overall assessment of the gloves (part 3) and the ranking of the models in order of preference (part 4).

All the results for the defence/restraint-and-control police group show that gloves HX 9005 and WM 006 have the best potential for meeting the officers' dexterity and tactile sensitivity needs. The two models were rated 1.3/4 and 1.6/4, respectively, for dexterity and tactile sensitivity, compared with 2.0/4 or higher (a higher score means manipulation is more difficult) for the other models. According to the subjects, models HX 9005 and WM 006 are also the ones that are the most comfortable (1.3/4 and 1.7/4, respectively) and the most flexible (1.0/2). These two models are also among the top three of all three subjects, with average overall ratings of 7.3/10 and 7.0/10.

Table 5 Evaluation of five models of glove by three subjects in police group – defence/restraint and control

Questionnaire sections Police – defence/restraint, control	**Glove models**														
	WM 003			**HX 4041**			**HX 4042**			**WM 006**			**HX 9005**		
1) Dexterity and tactile sensitivity for indicated competencies (1 Easy to 4 Hard)	**2.1**			**2.4**			**2.0**			**1.6**			**1.3**		
Subjects	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*
Use pepper spray	2.4	2.0	1.8	2.1	2.3	3.2	2.4	2.6	1.5	1.4	1.4	2.0	1.4	1.3	1.2
Use expandable baton	1.4	1.0	2.8	1.3	1.0	3.1	1.5	1.3	1.5	1.0	1.1	1.6	1.1	1.0	1.1
Use flashlight	2.0	2.0	2.5	2.3	3.0	3.3	2.0	4.0	2.3	1.3	1.3	2.3	1.8	1.8	2.0
Use handcuffs	2.1	2.1	2.4	2.8	4.0	3.1	2.5	4.0	2.1	1.3	1.5	2.5	1.6	1.0	1.6
Search techniques	1.8	2.0	2.8	1.8	2.0	2.6	2.0	2.0	2.2	1.3	2.0	2.2	1.3	1.6	1.8
Restraining techniques	2.0	3.0	2.2	2.6	2.2	2.4	2.4	2.2	1.8	1.2	2.2	2.4	1.4	1.4	1.8
Use emergency button on two-way radio	3.0	1.0	4.0	3.0	3.0	4.0	4.0	3.0	2.0	1.0	4.0	3.0	3.0	3.0	2.0
2) Glove characteristics (1 Satisfactory)	**2.2**			**1.9**			**1.6**			**1.3**			**1.1**		
Comfort (1 Satisfactory to 4 Unsatis.)	3.7			2.7			2.0			1.7			1.3		
Flexibility (1 Flexible, 2 Stiff)	2.0			1.7			1.3			1.0			1.0		
Grip when dry (1 Satisfactory, 2 Slippery)	1.3			1.0			2.0			1.3			1.0		
Grip when wet (1 Satisfactory, 2 Slippery)	1.7			2.0			1.0			1.0			1.0		
3) Overall assessment (10/10 Excellent)	**4/10**			**5/10**			**6.3/10**			**7/10**			**7.3/10**		
Subjects	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*
Overall assessment (/10)	4	5	3	6	6	3	6	7	6	7	8	6	8	7	7
4) Ranking (1 Best)	**5**			**4**			**3**			**2**			**1**		
Subjects	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*	*S1*	*S2*	*S3*
Ranking	5	5	5	3	3	4	4	4	2	2	1	3	1	2	1

Model HX 4042 also has some potential for meeting the dexterity and tactile sensitivity needs of the defence/restraint-and-control police group. However, testing revealed it to be very slippery in dry conditions because of the synthetic suede palm. The glove seems to offer a better grip when wet. In contrast with the subjects in the pistol-shooting group (in particular, subjects 2 and 3), those in the defence/restraint-and-control group did not find model WM 003 to be suitable at all. As Table 5 shows, they ranked it fifth out of five and gave it an overall rating of 4.0/10 on average.

The main comments made by the defence/restraint-and-control group, though of limited significance because of the small sample size, are as follows:

- Glove models WM 003, HX 4041 and HX 4042 are too slippery to wear when using pepper spray, an expandable baton or a flashlight, or when attempting to restrain someone by applying a joint lock.
- Models WM 003, HX 4041 and HX 4042 are stiff and too thick, and do not provide sufficient tactile sensitivity in the fingertips to frisk an individual satisfactorily, feel a joint lock has been applied properly or even feel whether a button has been pressed properly (flashlight, expandable baton, two-way radio).
- Using the emergency button on a two-way radio does not require much pressure. However, with the tested gloves, it is hard to be sure that it has been pressed properly, as some of the gloves are too thick or the fingertips too long.

The tasks police officers must perform in their work are complex and require a great deal of dexterity and tactile sensitivity, whether to handle a pistol, defend themselves or others, or restrain and control individuals. Naturally, the gloves they wear must be cut- and needlestick-resistant, but must also provide them with a very high level of dexterity and tactile sensitivity. Officers whose gloves interfere with their use of equipment and firearms may be exposing themselves to serious risks.

To sum up, none of the five glove models tested was suitable for pistol shooting, which demands fine dexterity and good tactile sensitivity for the delicate handling required. However, model WM 006 was rated the best, essentially because it was considered to be the most comfortable. For defence techniques and restraint-and-control tasks, models HX 9005 and WM 006 were deemed to offer the best potential. The other models were found to be too slippery and therefore unsuitable for handling police equipment.

3.2 Garbage Collectors

The suitability of selected models of protective gloves for garbage collection was evaluated by employees in the course of regular manual pickup of household trash. The subjects worked their usual routes, wearing four different models of gloves, in varied summer weather conditions and then provided feedback by filling in a perception questionnaire.

Two of the seven subjects recruited at the outset filled in and submitted their questionnaires. The other subjects withdrew from the study because they left their jobs with the garbage collection department in the targeted geographic area before the end of the study. The results presented here therefore reflect the opinions of only two subjects, one man and one woman. The ratings by the two subjects were averaged, nonetheless, to make the evaluation easier to read. The subjects performed a dozen or so garbage-collection tasks, which were grouped under three competencies. Table 6 gives their evaluation of the gloves in terms of dexterity and tactile sensitivity for the listed competencies (part 1), their ratings of glove comfort, flexibility and grip (part 2), their overall assessment of the gloves (part 3) and the ranking of the models in order of preference (part 4).

The evaluation of dexterity and tactile sensitivity showed that, in general, the subjects found it fairly easy to perform the different types of job-specific handling, even if a certain amount of effort was sometimes required. All gloves scored better than 2/4. The models that seemed to have the best potential were HX 9005 and HX 4041 for dexterity and tactile sensitivity, as well as for comfort and flexibility. Model HX 4041 seemed to be too slippery, however, whereas with model HX 9005, grip was satisfactory. The best grip, in both dry and wet conditions, was provided by model HX 9014, with its rubber coating.

Table 6 Evaluation of four models of glove by two subjects in garbage collectors group

Questionnaire sections Garbage collectors	**Glove models**							
	HX 9014		**HX 4041**		**HX 8030**		**HX 9005**	
1) Dexterity and tactile sensitivity for indicated competencies (1 Easy to 4 Hard)	**1.8**		**1.5**		**1.9**		**1.2**	
Subjects	*S1*	*S2*	*S1*	*S2*	*S1*	*S2*	*S1*	*S2*
Use “ring” hold to pick up garbage bags	3.0	1.5	2.5	1.7	3.0	1.7	1.5	1.0
Collection of household garbage in general	2.2	1.3	1.3	1.4	2.0	1.7	1.3	1.3
Safety issues	2.0	1.0	1.0	1.0	1.7	1.3	1.0	1.0
2) Glove characteristics (1 Satisfactory)	**1.6**		**1.8**		**2.0**		**1.3**	
Comfort (1 Satisfactory to 4 Unsatisfactory)	2.5		2.0		3.0		1.5	
Flexibility (1 Flexible, 2 Stiff)	2.0		1.0		2.0		1.0	
Grip when dry (1 Satisfactory, 2 Slippery)	1.0		2.0		1.0		1.0	
Grip when wet (1 Satisfactory, 2 Slippery)	1.0		2.0		2.0		1.5	
3) Overall assessment (10/10 Excellent)	**6.5/10**		**6.5/10**		**5.5/10**		**8.5/10**	
Subjects	*S1*	*S2*	*S1*	*S2*	*S1*	*S2*	*S1*	*S2*
Overall assessment (/10)	4	9	6	7	5	6	7	10
4) Ranking (1 Best)	**3**		**2**		**4**		**1**	
Subjects	*S1*	*S2*	*S1*	*S2*	*S1*	*S2*	*S1*	*S2*
Ranking	4	2	2	3	3	4	1	1

These observations are also reflected in the overall assessment of the gloves. The two subjects’ preferred model was HX 9005, which they gave an overall rating of 8.5/10 (see Table 6). Models HX 4041 and HX 9014 came in second, tied at 6.5/10.

The main comments made by the subjects in the garbage collectors group are as follows:

- With models HX 9014 and HX 8030, a lot of folds form in the palm when the hand is closed, causing irritation and discomfort.
- Model HX 4041 is too slippery. In addition, the lining moves around, making it very hard to put the gloves on and take them off, especially with wet hands.

The glove deemed most suitable for garbage collection was model HX 9005. The rubber coating of model HX 9014 was rated highly for the grip it offers, dry and wet. These results have limited significance, however, because of the small sample size.

3.3 Gardeners

The suitability of the gloves for gardening work was tested by gardeners in the course of their regular work, in varied summer weather conditions. The subjects wore three different models of gloves to weed and prune rosebushes and then gave their feedback by filling in a perception questionnaire.

One of the three subjects recruited at the outset withdrew from the study for personal reasons unrelated to the research project. The results presented in this section therefore reflect only the opinions of the two subjects who completed the testing (one man and one woman). The ratings were averaged, nonetheless, to make the evaluation easier to read. Table 7 gives the dexterity and tactile sensitivity ratings for 15 manipulations grouped under three competencies (part 1), the evaluation of comfort, flexibility and grip (part 2), the overall assessment of the gloves (part 3) and the ranking of the different models (part 4).

Generally speaking, the two subjects had very similar opinions about the three models of glove tested. They rated models HX 4042 and HX 9005 higher than model HX 4041 for all types of handling requiring fine dexterity and good tactile sensitivity. For weeding and rosebush pruning, the average score was 1.3/4 for models HX 4042 and HX 9005, while it was 2.6/4 (i.e., worse) for model HX 4041 (Table 7). Model HX 4041, which was found to be less suitable for gardening in terms of dexterity and tactile sensitivity, does provide satisfactory grip, however, in both dry and wet conditions. Model HX 4042 was deemed to be the most comfortable (scoring 1/4). The two subjects ranked the gloves in the same order of preference: the best one being HX 9005 (average overall assessment of 8.3/10), followed by HX 4042 (6.8/10), with the lowest score going to model HX 4041 (5/10).

With all three models, the subjects found it fairly difficult to prune rosebushes without getting pricked by thorns or to move rosebush branches without the gloves getting caught on thorns, branches or leaves, as the score of 3/4 for resistance to rosebush thorns indicates.

Table 7 Evaluation of three models of glove by two subjects in gardeners group

Questionnaire sections Gardeners	**Glove models**					
	HX 4041		**HX 4042**		**HX 9005**	
1) Dexterity and tactile sensitivity for indicated competencies (1 Easy to 4 Hard)	**2.6**		**1.3**		**1.3**	
Subjects	*S1*	*S2*	*S1*	*S2*	*S1*	*S2*
Weeding	2.7	2.4	1.0	1.0	1.0	1.0
Rosebush pruning	2.4	2.4	1.0	1.0	1.0	1.0
Resistance to rosebush thorns	3.0	3.0	3.0	3.0	3.0	3.0
2) Glove characteristics (1 Satisfactory)	**1.6**		**1.1**		**1.4**	
Comfort (1 Satisfactory to 4 Unsatis.)	2.5		1.0		2.0	
Flexibility (1 Flexible, 2 Stiff)	2.0		1.0		1.0	
Grip when dry (1 Satisfactory, 2 Slippery)	1.0		1.0		1.0	
Grip when wet (1 Satisfactory, 2 Slippery)	1.0		1.5		1.5	
3) Overall assessment (10/10 Excellent)	**5/10**		**6.8/10**		**8.3/10**	
Subjects	*S1*	*S2*	*S1*	*S2*	*S1*	*S2*
Overall assessment (/10)	5	5	7.5	6	8.5	8
4) Ranking (1 Best)	**3**		**2**		**1**	
Subjects	*S1*	*S2*	*S1*	*S2*	*S1*	*S2*
Ranking	3	3	2	2	1	1

The significance of the gardeners' comments is limited because of the small number of subjects who took part in the study. Their main comments are as follows:

- Model HX 4041 causes fingertip pain, probably because of the stitching and the thick fabric.
- None of the gloves is really waterproof enough for gardening.

To sum up, models HX 9005 and HX 4042 were rated the highest by the gardeners. However, neither model was very waterproof, although that is an essential property for gardening.

4. CONCLUSION

Not all the gloves tested in this study were developed specifically to meet the occupational requirements of police officers, garbage collectors or gardeners. However, given the lack of gloves on the market that offer some degree of needlestick resistance, workers who want to wear protective gloves have very little choice. Despite the small number of participants involved, the study provided an opportunity to document, on an exploratory basis, the suitability of existing glove models to meet these workers' requirements in terms of dexterity, tactile sensitivity and comfort. The evaluation results helped to identify the main advantages and irritants of the gloves, as well as the aspects that need to be improved, according to the different occupational groups.

Generally speaking, the gloves tested by police officers were not suitable for pistol shooting. The delicate manipulations that require fine dexterity (e.g., press magazine catch) or quick movements (e.g., fast reload) were hard to do while wearing gloves. The gloves did not provide sufficient tactile sensitivity for the wearer to be sure of having a good grip on the pistol without looking. While no glove seemed to have all the properties that would make it suitable for police tasks, model WM 006 was rated the highest. It was found to be slightly more comfortable and flexible than the others. For defence purposes and restraint-and-control tasks, models HX 9005 and WM 006 showed the best potential, in terms of dexterity and tactile sensitivity, as well as comfort, flexibility and grip. The other gloves (WM 003, HX 4041 and HX 4042) proved to be too slippery and therefore unsuitable for handling pepper spray, expandable batons or flashlights. All the models need to provide greater tactile sensitivity, as it is hard for wearers to feel whether they have properly pressed the emergency button on the two-way radio, for instance.

Model HX 9005 seems to offer the best potential for meeting the needs of garbage collectors, not just in terms of dexterity and tactile sensitivity, but also comfort, flexibility and grip. The subjects found model HX 4041 to provide satisfactory dexterity and tactile sensitivity, but deemed it to be too slippery. A rubber coating, like the one on model HX 9014, was judged to be the best material for ensuring a good grip, in both dry and wet conditions.

The gardening group subjects thought that gloves HX 9005 and HX 4042 provided better dexterity and tactile sensitivity than glove HX 4041. Model HX 4042 was deemed to be the most comfortable, while model HX 4041 offered the best grip in wet conditions. However, no glove was waterproof enough to be really suitable for gardening.

Overall, the most flexible models offer the best dexterity and tactile sensitivity and are the most comfortable. However, they also provide less needlestick resistance, such as model HX 9005 (only one layer of SuperFabric® in the palm) and model WM 006 or model HX 4042 (two layers of SuperFabric®), which the gardeners preferred to model HX 4041 (three layers of SuperFabric®). In addition, the fabric of the palm on most of the gloves tested tends to bunch into folds when the hand closes, causing irritation and discomfort. Moreover, the stitching often makes the gloves uncomfortable and diminishes tactile sensitivity. The lining of models HX 4041 and HX 4042 is not attached to the rest of the glove (being sewn only at the wrist), so that it came out when the wearer took the glove off. This makes it hard to remove the gloves and put them back on, especially with wet hands (feedback from both police officers and garbage collectors).

5. STUDY LIMITATIONS AND RECOMMENDATIONS

This was an **exploratory** study. Its principal limitation was the very small number of subjects who took part in the testing, and even smaller number who completed it, especially in the two occupational groups of garbage collectors and gardeners. The test results and feedback are therefore valid only for the small groups of workers who were recruited for the study.

A further limitation of the study is that some glove models were not specifically developed for the occupational groups that tested them, which means they obviously do not have all the characteristics required to meet those workers' needs, whether dexterity, tactile sensitivity or comfort, or with respect to grip and waterproofing.

To our knowledge, the study is the first on a worker evaluation of the dexterity and tactile sensitivity offered by various models of needlestick-resistant gloves. Despite its limitations, it identifies some major advantages and irritants of the gloves with regard to dexterity and comfort. It has thus expanded our knowledge about the suitability of existing models of gloves to meet the needs of three different occupational groups.

For a more objective appraisal of the dexterity afforded by the gloves, the subjective evaluation could have been complemented by conducting laboratory measurements of dexterity with several subjects. These measurements, which could not be done as part of the current study, would have provided an objective ranking of wearer dexterity that could have been compared with the subjective ranking made by the test participants in the workplace.

To improve the suitability of the gloves to meet workers' needs, manufacturers should get involved from the outset in a similar study with targeted occupational groups. They could work on improving or developing one or more models in cooperation with workers and researchers. A joint undertaking of this kind would help manufacturers learn more about workers' needs in terms of functionality (i.e., the glove's suitability for the task) and address those needs better, as was done earlier in another study on the risks of workers suffering cuts at a household appliance manufacturer [50]. Furthermore, a much larger number of subjects in each occupational group should be recruited to test the gloves.

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APPENDIX A: QUESTIONNAIRE – POLICE – PISTOL SHOOTING

Pistol shooting Results – Course of fire

Pistol Shooting – Course of Fire Results

Participant ID code: _____

Date of testing: *(dd/mm/year)*		Dry tests	Wet tests
	Glove A	/ / 2008	/ / 2008
	Glove B	/ / 2008	/ / 2008
	Glove C	/ / 2008	/ / 2008
	Glove D	/ / 2008	/ / 2008
	Glove E	/ / 2008	/ / 2008
	Barehanded	/ / 2008	/ / 2008
	Service glove	/ / 2008	/ / 2008

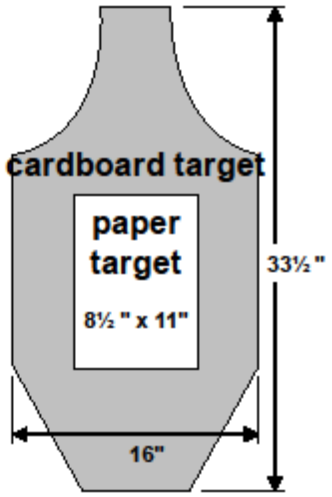
Circle the size you chose for each model of glove.

	Manufacturer	Model name	Model no.	Size worn
A	Warwick Mills	TurtleSkin Special Ops	TCC-003	xs s m l xl xxl
B	HexArmor	HiDex NSR	4041	6 7 8 9 10 11
C	HexArmor	HiDex NSR Leather	4042	6 7 8 9 10 11
D	Warwick Mills	TurtleSkin Duty	TUS-006	s m l xl xxl
E	HexArmor	9005	9005	7 8 9 10 11

bh	Barehanded	n/a	n/a	n/a
sg	Service gloves			

Indicate below the **number of shots** (max. 30) that hit the target for each form of handwear tested.

Handwear	Dry tests		Wet tests	
	Paper target	Card. target	Paper target	Card. target
A				
B				
C				
D				
E				
Barehanded				
Service gloves				



Pistol Shooting – Glove Perception Questionnaire

1. Dexterity and tactile sensitivity

Rate your ability to perform the manoeuvres listed below while wearing the gloves in question, on a scale of 1 to 4:

1. Very easy or fairly easy
2. Reasonably doable, but requiring some effort
3. Rather hard
4. Very hard

	Dry gloves							Wet gloves						
Draw, reholster	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**
1.1 Swivel semirigid strap forward (level 1 retention)														
1.2 Unholster pistol (level 2 retention)														
1.3 Reholster pistol (put back in holster)														
1.4 Reholster without looking														
1.5 Swivel semirigid strap backward														
1.6 Do quick draw (stage 5, course of fire)														
Load, reload, unload	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**
1.7 Press magazine catch to remove magazine														
1.8 Open magazine holder (snap ☐ or Velcro ☐)														
1.9 Remove magazine from holder														
1.10 Feel first round in magazine using index finger														
1.11 Insert magazine in pistol without looking														
1.12 Tap: Strike bottom of magazine to make sure it is seated properly														
1.13 Cycle: Pull slide back sharply														
1.14 Do fast reload (stage 3, course of fire)														
Shoot	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**
1.15 Hold pistol firmly, as you usually do														
1.16 Insert finger in trigger guard														
1.17 Pull trigger in one smooth, continuous motion														
1.18 Pull trigger in straight line along trigger axis														
1.19 Feel trigger as pistol fires														

Pistol shooting

Perception questionnaire – Gloves

	Dry gloves							Wet gloves						
1.20 Shoot accurately (point shooting or precision shooting) (stages 1 and 2, course of fire)														
1.21 Shoot fast (stages 4 and 5, course of fire)														
Clear jam – Level 1 method: Tap-Rack-Ready	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**
1.22 Tap: Strike bottom of magazine to make sure it is seated properly														
1.23 Rack: Pull slide back sharply to feed fresh round into chamber														
1.24 Ready: Take ready-to-fire position														
Clear jam – Level 2 method: Lock-Rip-Cycle-Tap-Rack-Ready	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**
1.25 Lock: Press catch to lock slide back														
1.26 Rip: Remove magazine														
1.27 Cycle: Pull slide back sharply twice to eject round from chamber														

2. General characteristics and comfort

Rate the glove with respect to the following characteristics.

		sg	**A**	**B**	**C**	**D**	**E**
2.1	Comfort 1. Very comfortable 2. Fairly comfortable 3. Fairly uncomfortable 4. Very uncomfortable						
2.2	General dexterity 1. Very good 2. Fairly good 3. Fairly poor 4. Very poor						
2.3	Tactile sensitivity in general 1. Very good 2. Fairly good 3. Fairly poor 4. Very poor						
2.4	Fit with respect to						
a)	Palm 1. Satisfactory 2. Too loose 3. Too tight						
b)	Thumb length 1. Satisfactory 2. Too long 3. Too short						
c)	Index finger length 1. Satisfactory 2. Too long 3. Too short						
d)	Length of other fingers 1. Satisfactory 2. Too long 3. Too short						
2.5	Flexibility 1. Flexible enough 2. Too stiff						
2.6	Grip when dry 1. Satisfactory 2. Too sticky 3. Too slippery						
2.7	Grip when wet 1. Satisfactory 2. Too sticky 3. Too slippery						
2.8	Breathability 1. Good 2. Makes hands sweat						
2.9	Putting on 1. Easy 2. Hard						
2.10	Taking off 1. Easy 2. Hard						

Pistol shooting Perception questionnaire – Gloves

3. Overall assessment

3.1 Rank the glove models according to their suitability for pistol shooting, with 1 being the most suitable and 6 the least. As your benchmark, assume that your regular service gloves are the most suitable model (unless that's not the case).

A ☐ B ☐ C ☐ D ☐ E ☐ sg ☐ 1

3.2 Rate each glove according to its suitability for pistol shooting, on a scale of 1 to 10, with 10 being excellent and 1 being poor. As your benchmark, assume that bare hands would score 10.

A _____ B _____ C _____ D _____ E _____ sg _____ bh _____ 10

3.3 Which glove model or models do you think it would be worthwhile to continue testing?

_____

3.4 What improvements would you like to see in the gloves?

_____

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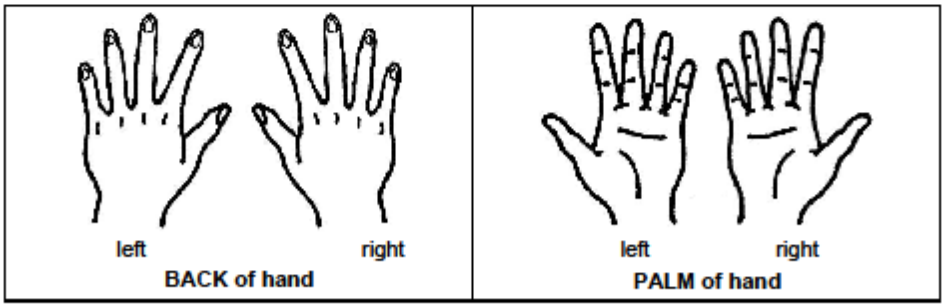
3.5 In your opinion, in what <u>key areas</u> should gloves protect against needlesticks? Shade or colour in the key areas.



APPENDIX B: QUESTIONNAIRE – POLICE – DEFENCE/RESTRAINT

Defence/Restraint and Control – Glove Perception Questionnaire

Participant ID code: _____

Date of testing: *(dd/mm/year)*		Dry tests	Wet tests
	Glove A	/ / 2008	/ / 2008
	Glove B	/ / 2008	/ / 2008
	Glove C	/ / 2008	/ / 2008
	Glove D	/ / 2008	/ / 2008
	Glove E	/ / 2008	/ / 2008
	Barehanded	/ / 2008	/ / 2008
	Service glove	/ / 2008	/ / 2008

Circle the size you chose for each model of glove.

#	Manufacturer	Model name	Model no.	Size worn
A	Warwick Mills	TurtleSkin Special Ops	TCC-003	xs s m l xl xxl
B	HexArmor	HiDex NSR	4041	6 7 8 9 10 11
C	HexArmor	HiDex NSR Leather	4042	6 7 8 9 10 11
D	Warwick Mills	TurtleSkin Duty	TUS-006	s m l xl xxl
E	HexArmor	9005	9005	7 8 9 10 11

bh	Barehanded	n/a	n/a	n/a
sg	Service gloves			

1. Dexterity and tactile sensitivity

Rate your ability to perform the manoeuvres listed below while wearing the gloves in question, on a scale of 1 to 4:

1. Very easy or fairly easy
2. Reasonably doable, but requiring some effort
3. Rather hard
4. Very hard

		Dry gloves							Wet gloves						
Pepper spray		*bh*	*sg*	A	B	C	D	E	*bh*	*sg*	A	B	C	D	E
1.1	Open holder (snap ☐ or Velcro ☐)														
1.2	Remove can from holder														
1.3	Handle can, hold in correct position														
1.4	Feel can is in correct position without looking														
1.5	Spray using index finger														
1.6	Spray using thumb														
1.7	Replace can in holder														

Defence/Restraint and control

Perception questionnaire – Gloves

	Dry gloves							Wet gloves						
Expandable baton	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**
1.8 Remove baton from holder														
1.9 Deploy in collapsed configuration														
1.10 Deploy in expanded configuration														
1.11 Warding off – Shoulder position														
1.12 Warding off – Lamb method														
1.13 Warding off – Jab with tip														
1.14 Blocking techniques														
1.15 Retention technique – Push-pull														
1.16 Retention technique – Tracing C														
1.17 Press button to collapse baton (action not common in stressful situations)														
1.18 Replace baton in holder														
Flashlight	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**
1.19 Remove flashlight from holder (snap ☐ or Velcro ☐)														
1.20 Press button to turn light on														
1.21 Handle flashlight – Harries position														
1.22 Replace flashlight in holder														
Handcuffs	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**
1.23 Open handcuff case (snap ☐ or Velcro ☐)														
1.24 Take cuffs out of case and hold them in position, without looking														
1.25 Grasp subject's thumb without it slipping, be able to feel joint lock applied properly														
1.26 Put on first cuff and close it														
1.27 Put on second cuff and close it														
1.28 Take out handcuff key														
1.29 Lock cuffs with key														
1.30 Take cuffs off safely														
Search techniques – Standing, cooperative subject	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**
1.31 Contact without violence – Grasp subject's elbow														
1.32 Frisk – Knife (rubber) on subject														
1.33 Frisk – Syringe (simulated) on subject														
1.34 Frisk – Handcuff key on subject														
1.35 Search – Grasp clothing (shirt collar)														

Defence/Restraint and control — Perception questionnaire – Gloves

	Dry gloves							Wet gloves						
Apply joint lock techniques	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**
1.36 Joint locks – Pulling														
1.37 Joint locks – Release														
Teamwork techniques	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**
1.38 Subject in prone position – Apply restraining belt														
Pressure points	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**
1.39 Apply pressure to mandibular angle – Sitting subject														
1.40 Apply pressure to hypoglossal – Sitting subject														
Using police equipment	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**	***bh***	***sg***	**A**	**B**	**C**	**D**	**E**
1.41 Two-way radio – Use 10-07														
1.42 Use vehicle 10-07														
1.43 Use 10-07 on on-board computer														

2. General characteristics and comfort

Rate the glove with respect to the following characteristics.

		sg	**A**	**B**	**C**	**D**	**E**
2.1	Comfort — 1. Very comfortable 2. Fairly comfortable 3. Fairly uncomfortable 4. Very uncomfortable						
2.2	General dexterity — 1. Very good 2. Fairly good 3. Fairly poor 4. Very poor						
2.3	Tactile sensitivity in general — 1. Very good 2. Fairly good 3. Fairly poor 4. Very poor						
2.4	Fit with respect to						
e)	Palm — 1. Satisfactory 2. Too loose 3. Too tight						
f)	Thumb length — 1. Satisfactory 2. Too long 3. Too short						
g)	Index finger length — 1. Satisfactory 2. Too long 3. Too short						
h)	Length of other fingers — 1. Satisfactory 2. Too long 3. Too short						
2.5	Flexibility — 1. Flexible enough 2. Too stiff						
2.6	Grip when dry — 1. Satisfactory 2. Too sticky 3. Too slippery						
2.7	Grip when wet — 1. Satisfactory 2. Too sticky 3. Too slippery						
2.8	Breathability — 1. Good 2. Makes hands sweat						
2.9	Putting on — 1. Easy 2. Hard						
2.10	Taking off — 1. Easy 2. Hard						

3. Overall assessment

3.1 Rank the glove models according to their suitability for pistol shooting, with 1 being the most suitable and 6 the least. As your benchmark, assume that your regular service gloves are the most suitable model (unless that's not the case).

A ☐ B ☐ C ☐ D ☐ E ☐ sg ☐ 1

3.2 Rate each glove according to its suitability for pistol shooting, on a scale of 1 to 10, with 10 being excellent and 1 being poor. As your benchmark, assume that bare hands would score 10.

A _____ B _____ C _____ D _____ E _____ sg _____ bh _____ 10

3.3 Which glove model or models do you think it would be worthwhile to continue testing?

_____

3.4 What improvements would you like to see in the gloves?

_____

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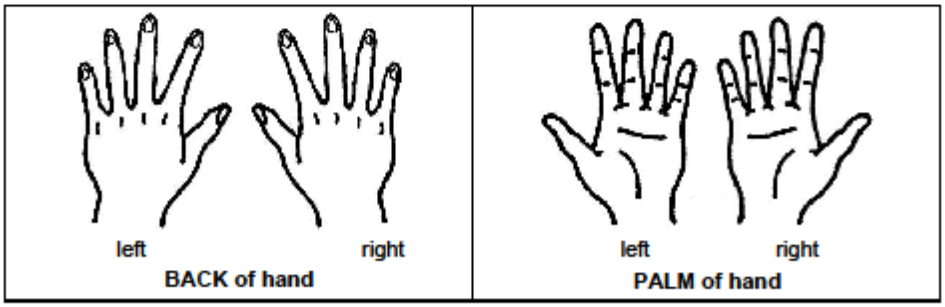
3.5 In your opinion, in what <u>key areas</u> should gloves protect against needlesticks? Shade or colour in the key areas.



APPENDIX C: QUESTIONNAIRE – GARBAGE COLLECTORS

Garbage Collectors – Glove Perception Questionnaire

Participant ID code: _____

Circle the size you chose for each model of glove.

	Manufacturer	Model name	Model no.	Colour	Size worn
A	HexArmor	Needle Defender	9014	orange	7 8 9 10 11
B	HexArmor	HiDex NSR	4041	black	6 7 8 9 10 11
C	HexArmor	8030	8030	yellow	7 8 9 10 11
D	HexArmor	9005	9005	grey	7 8 9 10 11

Indicate the model and size of glove you usually wear.

		Manufacturer and model no.	Size worn
g	Usual gloves		

Dates of glove testing and, in parentheses, approximate length of tests
[e.g., B: August 29, 2008 (0h20min), September 5, 2008 (1h10min)].

A _____

B _____

C _____

D _____

Garbage collectors Perception questionnaire – Gloves

1. Dexterity and tactile sensitivity

Rate your ability to perform the manoeuvres listed below while wearing the gloves in question, on a scale of 1 to 4:

1. Very easy or fairly easy
2. Reasonably doable, but requiring some effort
3. Rather hard
4. Very hard

Use "ring" hold to pick up garbage bags		*g*	A	B	C	D
1.1	Grab bags in "ring" hold without hands getting tired					
1.2	Grab bags in "ring" hold without hands getting tired even in cold, wet weather					
1.3	Feel bunching of bags in your hand when grabbing in "ring" hold (without needing to look)					
1.4	Get good grip, without irritating folds in glove material					
General collection of household garbage		*g*	A	B	C	D
1.5	In dry weather, pick up bags without having them slip out of your hands					
1.6	In wet weather (bags wet from rain), pick up bags without having them slip out of your hands					
1.7	Feel shape of objects to be handled, without having too much difficulty bending your fingers					
1.8	Make fine movements to grasp small items, pick up several small bags at once, operate hopper levers, etc.					
1.9	Throw bags into hopper without gloves slipping off hands and being pulled along with bags					
1.10	Pick up, pull or push heavy objects					
1.11	Feel weight of objects through gloves					
Other (safety issues)		*g*	A	B	C	D
1.12	Hold onto truck's grab bar without slipping					
1.13	Hold onto truck's grab bar without hands getting tired					
1.14	Don't get stuck to an object, garbage or truck, don't run risk of being pulled into compactor					

Garbage collectors Perception questionnaire – Gloves

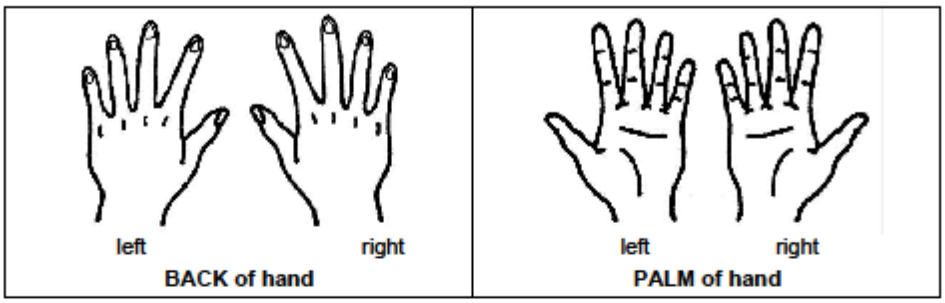
2. General characteristics and comfort

Rate the glove with respect to the following characteristics.

		g	A	B	C	D
2.1	Comfort 1. Very comfortable 2. Fairly comfortable 3. Fairly uncomfortable 4. Very uncomfortable					
2.2	General dexterity (ease of movement) 1. Very good 2. Fairly good 3. Fairly poor 4. Very poor					
2.3	Tactile sensitivity in general 1. Very good 2. Fairly good 3. Fairly poor 4. Very poor					
2.4	Fits shape of hand, without uncomfortable folds forming 1. Fits well, without folds forming 2. Folds form, but do not interfere 3. Does not fit well and folds form that interfere					
2.5	Fit with respect to					
a)	Palm 1. Satisfactory 2. Too loose 3. Too tight					
b)	Thumb length 1. Satisfactory 2. Too long 3. Too short					
c)	Index finger length 1. Satisfactory 2. Too long 3. Too short					
d)	Length of other fingers 1. Satisfactory 2. Too long 3. Too short					
2.6	Flexibility 1. Flexible enough 2. Too stiff					
2.7	Grip when dry 1. Satisfactory 2. Too sticky 3. Too slippery					
2.8	Grip when wet 1. Satisfactory 2. Too sticky 3. Too slippery					
2.9	Breathability 1. Good 2. Makes hands sweat					
2.10	Breathability in hot weather 1. Good 2. Makes hands sweat					
2.11	Keep hands warm in cold weather 1. Satisfactory 2. Too hot 3. Too cold					
2.12	Keep hands dry in wet conditions 1. Hands dry 2. Hands dry, but cold 3. Hands wet					
2.13	Putting on 1. Easy 2. Hard					
2.14	Taking off 1. Easy 2. Hard					
2.15	What size are gloves when wet? 1. Same as when dry 2. Too big 3. Too small					

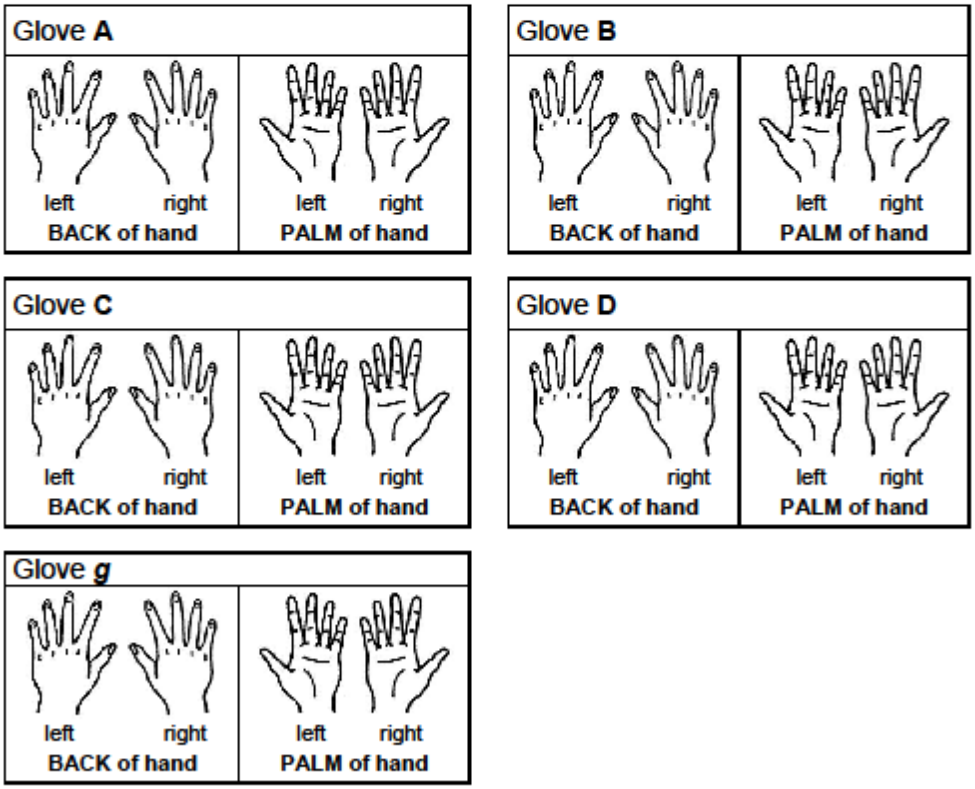
Garbage collectors Perception questionnaire – Gloves

2.16 In your opinion, in what key areas should gloves protect against needlesticks? Shade or colour in the key areas.



2.17 Are the gloves or their stitching uncomfortable, or do they irritate your skin?
Yes ☐ No ☐

If so, indicate where on your hand(s) and specify the type of discomfort (irritation, redness, blister, discomfort, open sore, folds in material, etc.).

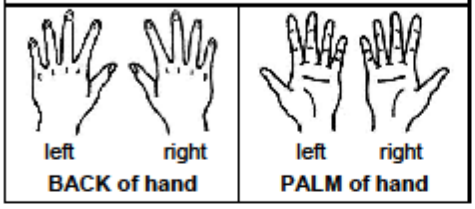


Garbage collectors

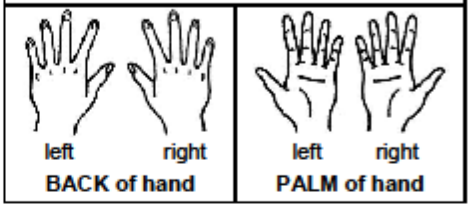
Perception questionnaire – Gloves

Do you find that the gloves wear out quickly? Yes ☐ No ☐
If so, indicate where on the gloves the wear occurs.

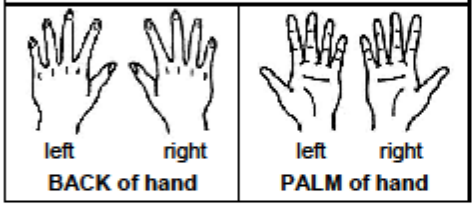
Glove **A**



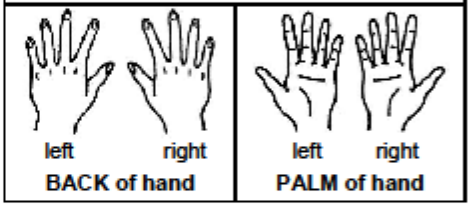
Glove **B**



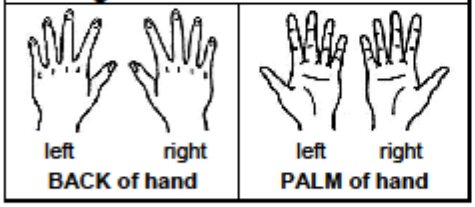
Glove **C**



Glove **D**



Glove ***g***



3. Overall assessment

3.1 Rank the glove models according to their suitability for pistol shooting, with 1 being the most suitable and 6 the least. As your benchmark, assume that your regular service gloves are the most suitable model (unless that's not the case).

A ☐ B ☐ C ☐ D ☐ E ☐ sg ☐ 1

3.2 Rate each glove according to its suitability for pistol shooting, on a scale of 1 to 10, with 10 being excellent and 1 being poor. As your benchmark, assume that bare hands would score 10.

A _____ B _____ C _____ D _____ E _____ sg _____ bh _____ 10

3.3 Which glove model or models do you think it would be worthwhile to continue testing?

_____

3.4 What improvements would you like to see in the gloves?

_____

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3.5 Feel free to add any other comments you would like to make.

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APPENDIX D: QUESTIONNAIRE – GARDENERS

Gardeners – Glove Perception Questionnaire

Participant ID code: _____

Circle the size you chose for each model of glove.

	Manufacturer	Model name	Model no.	Size worn
A	HexArmor	HiDex NSR	4041	6 7 8 9 10 11
B	HexArmor	HiDex NSR Leather	4042	6 7 8 9 10 11
C	HexArmor	9005	9005	7 8 9 10 11
g	Best usual glove	Nitri-Flex® Lite	4500	6 7 8 9 10

Dates of glove testing and, in parentheses, approximate length of tests
[e.g., B: May 6, 2008 (0h20min), May 15, 2008 (1h10min)].

A _____

B _____

C _____

1. Dexterity and tactile sensitivity

Rate your ability to perform the manoeuvres listed below while wearing the gloves in question, on a scale of 1 to 4:

1. Very easy or fairly easy
2. Reasonably doable, but requiring some effort
3. Rather hard
4. Very hard

Weeding		A	B	C
1.1	Do general weeding with sufficient dexterity (ease of hand movement)			
1.2	Be able to feel plants with your fingers			
1.3	Distinguish different parts of plants (branches, stems, leaves, flowers, etc.) by feel			
1.4	Remove weeds by hand with dexterity (ease of hand movement)			
1.5	Grasp plants to pull them out			
1.6	Use hand tools (rake, weeding tools, secateurs/shears, etc.) without losing grip			
1.7	Use hand tools without losing grip, even when gloves are wet			
1.8	Hold hand tools without hands getting tired (gloves flexible enough? gloves provide good enough grip?)			

Rosebush pruning	A	B	C
1.9 Generally prune rosebushes with sufficient dexterity (ease of hand movement)			
1.10 Handle different parts of rosebushes (stems, leaves, flowers, etc.) delicately (with sufficient dexterity, i.e., ease of hand movement)			
1.11 Distinguish different parts of rosebush (stems, leaves, flowers, etc.) by touch			
1.12 Pinch stems			
1.13 Move branches without gloves getting caught on thorns, branches or leaves			
1.14 Prune rosebushes without getting pricked by thorns			
1.15 Use hand secateurs/shears without losing grip			
1.16 Use hand secateurs/shears without losing grip, even when gloves are wet			
1.17 Grasp secateurs/shears without hands getting tired (gloves flexible enough? gloves provide good enough grip?)			

2. General characteristics and comfort

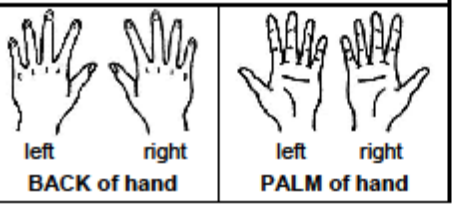
Rate the glove with respect to the following characteristics.

		A	B	C
2.1	Comfort 1. Very comfortable 2. Fairly comfortable 3. Fairly uncomfortable 4. Very uncomfortable			
2.2	General dexterity (ease of movement) 1. Very good 2. Fairly good 3. Fairly poor 4. Very poor			
2.3	Tactile sensitivity in general 1. Very good 2. Fairly good 3. Fairly poor 4. Very poor			
2.4	Fit with respect to			
e)	Palm 1. Satisfactory 2. Too loose 3. Too tight			
f)	Thumb length 1. Satisfactory 2. Too long 3. Too short			
g)	Index finger length 1. Satisfactory 2. Too long 3. Too short			
h)	Length of other fingers 1. Satisfactory 2. Too long 3. Too short			
2.5	Flexibility 1. Flexible enough 2. Too stiff			
2.6	Grip when dry 1. Satisfactory 2. Too sticky 3. Too slippery			
2.7	Grip when wet 1. Satisfactory 2. Too sticky 3. Too slippery			
2.8	Breathability 1. Good 2. Makes hands sweat			
2.9	Keep hands warm in cold weather 1. Satisfactory 2. Too warm 3. Not warm enough			
2.10	Keep hands dry in wet conditions 1. Hands dry 2. Hands dry, but too cold 3. Hands wet			
2.11	Putting on 1. Easy 2. Hard			
2.12	Taking off 1. Easy 2. Hard			

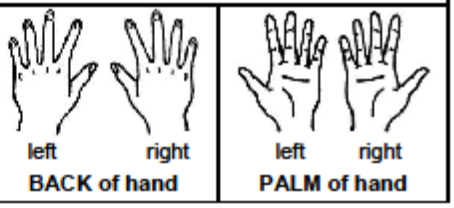
Gardeners Perception questionnaire – Gloves

2.13 Are the gloves or their stitching uncomfortable, or do they irritate your skin?
Yes ☐ No ☐
If so, indicate where on your hand(s) and specify the type of discomfort (irritation, redness, blister, discomfort, open sore, etc.).

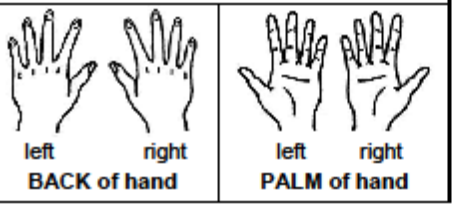
Glove **A**



Glove **B**

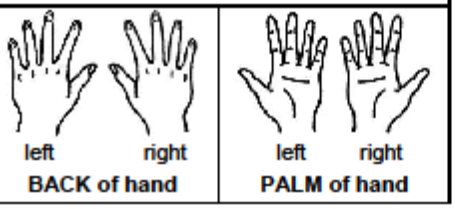


Glove **C**

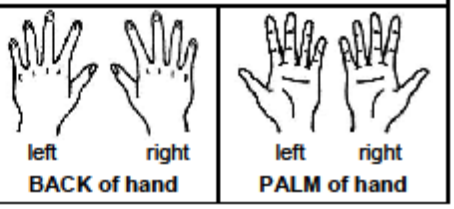


2.14 Do you find that the gloves wear out quickly? Yes ☐ No ☐
If so, indicate where on the gloves the wear occurs.

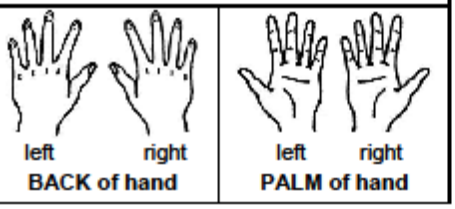
Glove **A**



Glove **B**



Glove **C**



3. Overall assessment

3.1 Rank the glove models according to their suitability for pistol shooting, with 1 being the most suitable and 6 the least. As your benchmark, assume that your regular service gloves are the most suitable model (unless that's not the case).

A ☐ B ☐ C ☐ 1

3.2 Rate each glove according to its suitability for pistol shooting, on a scale of 1 to 10, with 10 being excellent and 1 being poor. As your benchmark, assume that bare hands would score 10.

A _____ B _____ C _____ 10

3.3 Which glove model or models do you think it would be worthwhile to continue testing?

_____

3.4 What improvements would you like to see in the gloves?

_____

_____

_____

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3.5 Feel free to add any other comments you would like to make.

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